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EDITORIAL NOTES

GAS INDUSTRY RESEARCH

In happier times the Autumn Research Meeting of The Institution of Gas Engineers would have been held last month. In normal circumstances it would have been the twelfth of the series. As it is, the Institution, following the plan adopted last year, is publishing the various reports as blue books and is allowing the Technical Press to make what use of them they wish. That is, with one exception—a report giving the results of a preliminary study at the National Physical Laboratory of the noises emitted in the operation of certain types of gas appliance. The object was to place the investigation on a quantitative basis, to assist in devising means for quietening gas appliances which are the subject of complaints on the score of noise. We may mention at this stage that the appliances so far studied come within the category of domestic gas burners, comprising various kinds of gas fire and cooking and lighting burners, and that attention has been given to the loudness, composition, and origin of the various noises which occur. The other investigation which the National Physical Laboratory is carrying out for the Gas Research Board is concerned with the stresses imposed by the wind upon the structure of spirally guided gasholders. In our issue to-day we publish in full the first report of the Council of the Board, and hope to do justice subsequently to the other communications.

Concluding its report the Council states that it does not regard it with satisfaction. The reason is not far to seek. The outbreak of war diverted the attention of members of the Council to work of more pressing urgency than the building up of a broader research organization. There is compensation, however, in the fact that the Board has been able to assist Government Departments in many directions at a time of national necessity, and that a great deal of the fundamental research being undertaken prior to the war is being continued, though in some directions its tempo has had to be slowed down. The work of the Joint Research Committee on the complete gasification of coal has been continued on substantially the same lines as those laid down when this work was commenced, though special attention has been directed to the possibilities of using methane as a wartime fuel—the possibility of devising a process which could be put into operation quickly. As is pointed out in the report, however, this modification has not meant any serious departure from the lines originally planned, and the possibilities and limitations of catalysts in the synthesis of methane have been and are being studied in the closest co-operation with the Fuel Research Board. At the present time it is not considered in the national interest to publish detailed results of the investigation, but the difficulties which hitherto hindered the development of this process are becoming far more clearly understood and controllable. The difficulties " no longer appear as the formidable obstacles which they have been hitherto." The production of methane by the gasification of coal in hydrogen under pressure has not lost its interest, but circumstances arising from the war have made it impossible so far to proceed with the large scale experiments which had been planned in co-operation with the Fuel Research Board. There is, however, some possibility that other arrangements for the continuation of this work may be available.

It is trite to say that the work of the Gas Research Board is highly important. On the return of peacetime conditions, when reconstruction in so many directions will be necessary, the value of the work will be more evident ; and it does appear that with this reconstruction the need for a reasoned fuel policy for the nation will be recognized. The Board will have its rôle to play when national policy in regard to the utilization of fuel is being framed ; its past work will have an influence in the framing of this policy. A feature of the Board which, we feel certain, will in time be of great assistance to the Industry is a Bureau of Information. The idea was mooted years ago and has been discussed fully in these columns. From the beginning it has had our hearty support. We are aware that a Bureau of the type envisaged involves a great deal of work before it can function with full efficiency. In peacetime its organization would have taken time ; in wartime the time taken must be longer, but we think that the need is such that every effort possible should be made, in spite of prevailing difficulties, to establish a Bureau on sound working lines. In existing circumstances the project is not easy, but, though progress may be slower, the prosecution of the project should continue.

"FAVOURABLY PLACED"

" Gas companies taking bulk gas from coke ovens found themselves favourably placed and have not had to impose restrictions on their consumers." This quotation is taken from the Presidential Address of Mr. T. P. Carr to the Coke Oven Managers' Association. The Address was published in the " Journal " last week. Mr. Carr's comments were concerned with that—at the time and in the circumstances, at any rate—peculiar Regulation, the Fuel and Lighting Order, which imposed sundry restrictions. Since that Order, times have changed, and we think even that towns have changed in shape, due to " enemy action." So that some gas undertakings, as a result, are not so certain that " all one's eggs in one basket " is the best possible manner in which to ensure continuity of gas supply—continuity of the cheerful presence of Mr. Therm.

Not that coke oven gas should not be utilized to the best advantage. Not that gas undertakings should not pay an equitable price for it. What we are thinking about is the fundamental difference in point of view between the Gas Industry and the coke oven industry. The coke oven industry is under no obligation whatever about its gas. In the course of making " hard " coke—and we do not like the term—it makes gas. For many years most of the thermal value of that gas has been wasted, due to absence in this country of a national fuel policy.

We remember well the early days when the gas industry found for the coke oven industry a new market for its waste product—a profitable market for the coke oven industry. There were, among other minor matters, clauses about naphthalene content of the gas at the coke ovens at inlet to compressors. Were they observed ? This is no time for rancour. It is a time for co-operative thinking, for long-distance thought. " Gas companies taking bulk gas from coke ovens found themselves favourably placed and have not had to impose restrictions on their consumers." Without delving deeply into the meaning of this statement and what may or may not lie behind it, we do suggest that it is unhappy at the moment. It is not redolent of that spirit of co-operation on fuel problems, which is not merely desirable, but necessary. On occasion, due to " enemy action," gas supply has failed ; failure has been remedied more rapidly than consideration of exigencies would have led one to believe

possible. In point of fact, we are rather proud of the gas industry. Gas undertakings have their statutory obligations, and they have to maintain, even if taking, and, incidentally, paying for, coke oven gas, stand-by plant. And if one gas-making plant falls, or fails for some reason or another, curiously enough another stands. It makes gas for cooking meals, for warming rooms, for lighting. That this is so is due to the foresight of the gas industry. Can the coke oven industry claim to have organized for research in the same way that the gas industry has managed to organize? We appreciate the problems peculiar to both industries, but we have not been able to appreciate why the coke oven industry has, until comparatively recently, not "indulged" more in research. Is all the blame to be laid on the doorsteps of the coalowners? No, we are not enamoured of that extraordinary phase in Mr. Carr's Address. We need, and shall undoubtedly get, more co-operation between two important industries carbonizing nearly 40 million tons of coal annually in this country, for the benefit of industrial and domestic users of refined fuel.

Personal

Mr. RICHARD JOHN BRADSHAW has been appointed Engineer and Manager of Bridgnorth (Shropshire) Gas Department. He commenced his career as a chemist with the Blackpool Gas Department, and in 1929 he went to Macclesfield Gas Department as Assistant Engineer and Manager, a position he held until 1935. For the next three years he was assistant Engineer and Manager of Rochdale Corporation Gas Department, and two years ago he went to Bath in a similar capacity.

* * *

Mr. CHARLES B. S. MITCHELL, Assistant Gas Manager at Stirling, has been appointed Engineer and Manager at Dunfermline. Mr. Mitchell is an Associate Member of The Institution of Gas Engineers. He received his early training with West's Gas Improvement Co., Ltd., Manchester, and was for two years Assistant Continental Engineer at Tilburg, Holland.

* * *

Mr. R. J. RESTALL, Engineer and Manager of the Stalybridge Gas Department, was involved in a car accident on Nov. 18, and his many friends will be sorry to learn that he is suffering from an injury to the knee.

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Alderman Sir CLIFFORD TOZER has been re-elected Chairman and Mr. Louis Hodge Vice-Chairman of the Gas Committee of the Plymouth Corporation.

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Friends of Mr. F. C. WILSON will be sorry to learn that his private house has suffered by enemy action. His temporary address will be c/o Mr. E. H. Sharples, Sunnymeade, Leamington Road, Kenilworth. Tel. Kenilworth 699.

* * *

Mr. ALONZA SMITH, who is retiring from the position of Works Foreman at Darwen, has seen 40 years' service in the Gas Industry. Starting in his native city of Nottingham, he was employed at the gas-works there from 1900 to 1907, and he has since served at Hastings, Merthyr Tydfil, Accrington, Swadlincote, and Darwen.

* * *

Many in the Gas Industry will be interested to learn of a wedding which took place quietly in Edinburgh last month, when Mr. HAROLD E. BENNET, M.C., Director of Alder and Mackay, Ltd., married Miss Kathleen Grant, a daughter of Mr. William Grant, who is a Director of the same Company. Mr. Bennet is a grandson of one of the late Senior Partners, Mr. Joseph Bennet, and his wife is a granddaughter of the other, Mr. Alex. Mackay. The event, therefore, unites the two families sixty-six years after their entry into partnership. It will be recalled that Mr. Bennet was Chairman in 1933 of the S.B.G.I., in the affairs of which he has long played a most active and useful part. In this capacity he joined the British Delegation to the American Gas Congress of that year. His many friends will wish him and his wife long years of happiness.

* * *

The wedding took place last week of Mr. WILLIAM KIRK, Engineer and Manager of the Motherwell Gas Department, and Miss Nancy Rae, of Edinburgh. The ceremony was solemnized in Colinton Parish Church, near Edinburgh.

Forthcoming Engagements

Dec.

13.—I.G.E.—Liquor Effluents and Ammonia Committee, 12.15 p.m.
13.—Gas Research Board.—Joint Research Committee, 2 p.m.
19.—Gas Research Board.—Refractory Materials Joint Committee, 2 p.m.

(There will be no meeting of the Central Executive Board of the National Gas Council during the month of December.)

Obituary

The funeral took place at St. Margaret's Cemetery, Rochester, on Nov. 22, of C. VALON BENNETT. It was attended by many of his late colleagues in the Rochester, Chatham, and Gillingham Gas Company, by representatives of the South-Eastern Gas Corporation, and many Engineers and Managers of the constituent undertakings. The National Bodies of the Gas Industry and the Southern Association were also represented.

* * *

We announced briefly in the "JOURNAL" last week the death of Mr. WILLIAM KELLOCK, which took place at his residence, 7, Monieburgh Road, Kilsyth, on Nov. 19. A native of Alloa, Mr. Kellock was employed for a number of years at the Alloa Gas-Works under Mr. Yuill. He went to Kilsyth to take up duties as Gas Manager in 1901 and retired from this position in 1928. His eldest son, Mr. Archibald Kellock, is Gas Engineer and Manager at Airdrie.

The Price of Gas will be increased by 2½d. per 1,000 cu.ft. by the Carluke Gas Company, Ltd., in the first survey of 1941.

The Price of Gas in Falkirk was, some months ago, increased by 10d. per 1,000 cu.ft., and last week there has been a further increase of 1d. per thousand.

The Whessoe Foundry and Engineering Coy., Ltd., announce a change of address. The London offices are now established at Lane's Offices, Potten End, Berkhamsted, Herts. Telephone number Berkhamsted 10.

Mainly Owing to the increased cost of coal and other overhead charges the Gas Committee of the Plymouth City Council decided on Nov. 21 to recommend that after the Christmas readings of the meters in the Devonport area of the city the price of gas be advanced from 3s. 6d. to 4s. per 1,000 cu.ft.

New Gas Charges, to come into operation after the Nov. readings of the meters, were agreed to by the Oswaldtwistle District Council, on Nov. 20, as follow: Industrial scale, in excess of 720 therms per month increased from 3d. per therm, plus 10%, to 3.5d. per therm, plus 10%, subject to 2½% discount under the usual conditions; central heating and steam-raising charges, in excess of 480 therms per month to be increased from 3d. per therm, plus 10%, to 3.5d. per therm, plus 10%, subject to 2½% discount.

According to Alderman Sir Albert Ball, who has been re-elected Chairman of the Nottingham Gas Committee for the 37th time, gas consumption in Nottingham is on the increase in spite of the absence of street lighting and the resultant loss of revenue. The returns for the past six months, he said, showed a substantial increase, and it was apparent that there was a preference for gas where heating, cooking, and industrial requirements were concerned. Although the cost of production was up, he did not fear an increase in the price of gas, for the time being at any rate, and as far as the Committee were concerned they would do all in their power to keep the price down.

An Inexpensive Bowl Heater specially designed to meet present day requirements, and named "Warmglow," has been produced by Falk, Stadelmann, & Co., Ltd. It has a polished copper bowl reflector to give a cheerful and warming glow, and the radiant is made of almost indestructible perforated heat resisting steel to give long service without frequent renewals. The flat flame burner calls for a very low consumption of 6 cu.ft. per hour, and the heater is fitted with a wire dress guard and black finish cast iron stand. Its wartime selling point is that it produces a large amount of heat for a small amount of gas.

In the Course of an Address before the Carlisle Rotary Club, on the History of the Gas Industry, Mr. J. G. Aitken, Engineer and Manager of the Carlisle Corporation Gas Department, compared gas charges of 100 years ago with those of to-day. In 1840, he said, gas cost 8s. per 1,000 cu.ft. compared with 3s. 3d. to-day. Coal cost 7s. a ton against 30s.; coke brought 11s. against 33s. 4d. to-day; while at that time tar, at ½d. a gallon, was almost unsaleable. Mr. Aitken said that Carlisle Corporation took over the local Gas Company in 1851. From that time on the undertaking had progressed. In 1922 the Corporation built new gas-works capable of producing 3,000,000 cu.ft. of gas per day. During the past winter, continued Mr. Aitken, the estimated maximum output was all but reached on three consecutive days.

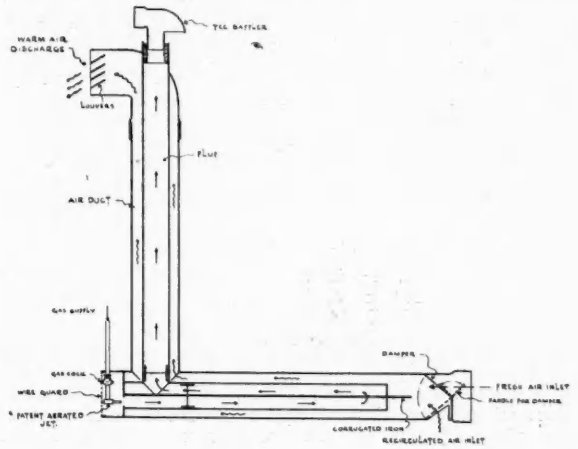
"Gas Journal" Directory

In order that readers may be able to keep the particulars contained in the "JOURNAL" Directory up to date, we summarize changes of which we have been advised during the past month:

Page 16. CHEPSTOW. J. Robb resigned.
" 26. FALMOUTH. E. H. Hart, E., resigned.
" 40. LICHFIELD. J. Robb appointed E., M., & S.
" 58. ROCHESTER. C. Valon Bennett, E., G.M., & S., deceased.
" 62. SITTINGBOURNE. C. Valon Bennett, G.M., deceased.
" 64. SOUTH MOLTON. E. H. Hart appointed E. & M.
" 84. DUNFERMLINE. C. B. S. Mitchell, appointed E. & M.

Warming and Ventilating Plant for Air-Raid Shelters

The accompanying diagram is of a new apparatus by Messrs. Thomas Potterton (Heating Engineers), Ltd., for the heating and ventilating of air-raid shelters. The plant is designed to warm shelters or other buildings by convection from the outer surfaces of the apparatus and by delivering warmed air either from the external atmosphere, or by re-circulating the air within the building, thereby obtaining the advantage of air movement.



The standard size has a gas consumption of approximately 50 cu.ft. per hour and will deliver 3,000 to 4,000 cu.ft. of fresh air into the building raised through a temperature rise of approximately 150°F.

The apparatus consists of a horizontal length of 5 in. Asbestone flue pipe, divided by an iron plate with corrugations forming the combustion chamber in the lower half and a return flue in the upper half. This return flue is continued by a vertical 5 in. Urastone pipe terminating with a tee baffler at the upper end, ready for extension to the external atmosphere.

The whole of the 5 in. pipe up to the baffler is enclosed in a 9 in. Urastone pipe which forms the air duct, the passage of air being accelerated by the natural draught in the vertical shaft, the discharge being in a downward direction through the louvred end.

The inlet end of the shaft is fitted with an adjustable damper to close the inlet opening from the building when fresh air is required from the external atmosphere, as would occur when the shelter is occupied for long periods or by a large number of persons, or alternatively, to close the opening from external atmosphere when it is desirable to re-circulate the air within the building, thereby economizing in gas consumption.

Complete combustion of the gases is obtained by the use of the Potterton patent aerated jet. This has been specially designed for burning gas in horizontal tubes, and the jet, together with the gas tap, is covered by a wire frame to prevent interference by unauthorized persons. The gas cock being of asylum pattern with a loose key and lock shield.

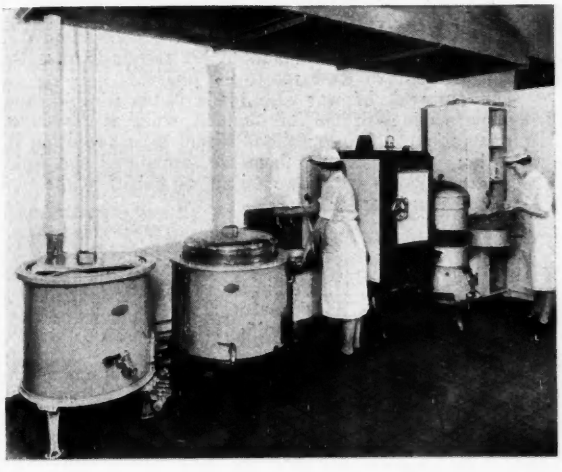
When installing this apparatus it is necessary to carry an extension from the external atmosphere to the inlet end in 9 in. pipe, also to extend the flue to discharge externally through a 3 in. pipe fitted with suitable terminal.

Crossley-Premier Engines

Reviewing their activities during the past twelve months, Crossley-Premier Engines, Ltd., Sandiacre, record that their contribution to the war effort is no less than their work of supplying the prime motive power to gas-works, generating stations, pumping stations, mines, essential power plants, and marine reciprocating machinery parts of all kinds in all parts of the Empire. One of their most recent activities has been the successful operation of a Crossley-Premier gas engine in Trinidad. This is direct coupled to a Metro-Vick alternator, and besides being the largest British-made set in the world operating on natural gas, it presents many novel features. It is of standard Crossley-Premier horizontal construction ; 12 cylinders are arranged in four groups of three. Two of these are placed *vis-à-vis* on each side of a centrally-disposed fly-wheel, the arms of which form the rotating field of the alternator. This engine operates in parallel with three Crossley heavy oil engine sets running at 335 revolutions and rated at 280 kw. The current generated is used for general service on one of the major oil-producing fields in the island, and includes the transfer of oil from the wells to a refinery 20 miles away

Air Filters for "Dry" Filtration

To meet the requirements of food factories, film works, instrument testing rooms and similar premises where the dust loading of the air is not heavy and the dust is of a very fine nature, and of buildings where facilities for cleaning air filters of the viscous type are not readily available, the Visco Engineering Co., Ltd., Stafford Road, Croydon, has introduced a dry filter with a " throw away " type of filter element. The Visco patent " C.E." filter is so designed that there is no risk of air by-passing the filter element. The filtering medium consists of special wadding pads which effectively extract the dust, while offering low resistance to the air flow. Maintenance costs are low, as the filter pads are inexpensive and only the filter medium itself needs renewing ; the soiled pads can be quickly and easily removed and disposed of without raising a dust. Where dust loadings are large and an extremely high degree of filtration is required, the dry filter can be used for second-stage filtration in conjunction with a standard air filter. Self-contained ventilating units are available containing three aluminium filter cells of the C.E." type, each holding two wadding filter pads. The capacity of the set is 600 cu.ft. of filtered air per minute against an external resistance of 0.75 in. W.G.



Our photographs are of the Communal Kitchen in Liverpool. The kitchen was opened by Lord Woolton recently and provides seated meals for 150 people. Working on a 24-hour basis, this means that continuous cooking can feed 4,800. Primarily these kitchens were intended for use in bombed areas where people were deprived of the means of cooking, but in Liverpool a large number of poor people are making daily use of the facilities available. The equipment consists of : 1 Benham steamer, 1 5-ft. hotcupboard with carving well, 2 8-pt containers, 1 4-tier Rota pan, 1 milk and porridge boiler, 1 rustless cast iron boiler, and 2 large gas cookers. All these are in the kitchen. In the cafeteria, beneath the counter, is a 15-ft. Stott hotcupboard with an 18 in. by 18 in. Bain Marie and a café-set with two 2-gall. urns. The hot water supply to the whole building is from a 60-gall. gas fired Solar hot water set.

INSTITUTION OF GAS ENGINEERS

1st ANNUAL REPORT OF THE COUNCIL OF THE RESEARCH BOARD

This Annual Report would normally form the means by which the Council of the Board would render an account of its stewardship to the members and an opportunity for discussion of the Report would be afforded at the Annual General Meeting of the Gas Research Board which would take place during the Autumn Research Meeting of The Institution of Gas Engineers. Owing to the present abnormal circumstances and for reasons which will become apparent on reading this Report, the nature of this document is somewhat different from that which, it is hoped, future Annual Reports will assume.

Officers and Council

The first meeting of the Council was held on 25th July, 1939, when the following appointments were announced:

President: Sir David Milne-Watson, Bt., D.L., M.A., LL.D.

Secretary: W. T. K. Braunholtz, M.A., Ph.D.

Members of Council:

Nominated by The Institution of Gas Engineers:

E. V. Evans, O.B.E.	(London; *Chairman*).
E. Crowther, M.Eng.	(Newcastle-upon-Tyne).
J. E. Davis	(London).
George Dixon, B.Eng.	(Nottingham).
H. Hollings, D.Sc.	(London).
Stephen Lacey, B.Sc.	(London).
C. A. Masterman, M.A.	(London).
T. F. E. Rhead, M.Sc.	(Birmingham).
H. C. Smith, J.P.	(London).

Nominated by the Society of British Gas Industries:

A. G. Grant, M.Sc.	(Darlington).
H. Hartley, D.Sc.	(Birmingham).
D. M. Henshaw	(Huddersfield).
R. J. Rogers	(Birmingham).
E. W. Smith, C.B.E., D.Sc.	(London).
E. West.	(Manchester).

It was resolved to invite Prof. D. T. A. Townend, D.Sc., Ph.D., D.I.C., to serve as a co-opted member of the Council.

The Councils of The Institution of Gas Engineers and of the Society of British Gas Industries were then invited each to nominate one Vice-President. The Institution of Gas Engineers nominated its President, Mr. George Dixon, B.Eng. (Nottingham), and the Society of British Gas Industries nominated Sir Frederick J. West, Kt., C.B.E., J.P. (Manchester).

It was evident that as the Board would require to raise funds and to expend them with a limited liability to its members, and as, at a later date, it would probably desire to obtain grant of letters patent covering its discoveries and to grant licences thereunder, it would be necessary for the Board to become a body corporate in the sense of the Companies Act, 1929, either by Trust Deed or by Articles of Association. The Council thereupon appointed the following Drafting Panel to draw up Articles of Association for submission to the Council and to the Board of Trade:

Drafting Panel

Mr. E. V. Evans (*Chairman*)
Mr. R. J. Rogers
Dr. E. W. Smith
Mr. H. C. Smith

In drafting the Articles of Association, regard has been paid to the possibility that at some future date the Gas Research Board might desire to become associated with the Department of Scientific and Industrial Research and, possibly, to receive a grant as a Research Association. The Department of Scientific and Industrial Research has, therefore, been consulted in the preparation of these Articles of Association in order to avoid there being included in them any matter which would be a hindrance to such association, should it be desired at a later date. The existing circumstances have made some delay in the drafting of this Constitution inevitable and although the draft Articles of Association have now been approved by the Council, the Gas Research Board has not yet become incorporated. Thus, strictly speaking, there are as yet no members but only potential members, and the obligation to hold an Annual General Meeting, which would have been highly inconvenient at the present time, does not yet become operative. The draft Articles of Association are, however, at the moment the subject of discussions with the Board of Trade and it is anticipated that the establishment of a normal Constitution will in the near future be completed and the position thereby regularized.

At its first meeting the Council also appointed the following

Finance Committee

Mr. H. C. Smith (*Chairman*)
Mr. E. V. Evans
Mr. D. M. Henshaw
Mr. Stephen Lacey
Dr. E. W. Smith

It will be appreciated that until such time as the Gas Research Board shall be incorporated, it has been necessary to make temporary financial arrangements. The Institution of Gas Engineers has agreed to meet the expenses of the Gas Research Board in the same way that it hitherto has met the research expenses of the Institution out of the Special Purposes Fund of the Institution. It is not proposed that, for the present at any rate, the Gas Research Board should possess separate offices or laboratories and the Council of The Institution of Gas Engineers has agreed to allow the use of its office facilities and staff at Gas Industry House for a charge agreed between the Finance Committees of the two bodies. A particularly valuable service which the Institution has rendered to the newly-formed Board is in giving permission for the Secretary, Dr. W. T. K. Braunholtz, to be the first Secretary of the Gas Research Board.

When the formation of the Gas Research Board was first considered, it was appreciated that the success of the venture would depend to a great extent upon the selection of an able and competent Director of Research. Shortly before the outbreak of war, applications for this position were invited by advertisements inserted in the technical press and in certain national periodicals. A number of applications were received but by that time the nation was at war and it was felt that, owing to the demands likely to be made upon the services of many of the applicants, it would be a most unsuitable time to make any appointment. With the consent of the Council of The Institution of Gas Engineers, the Secretary, Dr. W. T. K. Braunholtz, was asked to add to his responsibilities that of Acting Director of Research to the Board.

The outbreak of war also made it undesirable to hold regular meetings of the full Council, while at the same time it was probable that questions would arise requiring urgent attention. The Council, therefore, appointed the following Emergency Panel with power to act on behalf of the Council, should the need arise:

Emergency Panel

Mr. E. V. Evans (*Chairman*)
Dr. H. Hollings
Dr. E. W. Smith
Mr. H. C. Smith

This Emergency Panel has held frequent meetings during the year and has dealt with a number of urgent matters, particularly those arising from questions put to the Gas Research Board from time to time by various Government Departments.

Membership

It would probably be of general interest to indicate to whom invitations for membership will be extended when the incorporation of the Board is completed. The draft Articles of Association provide that, subject to certain safeguards, the Association shall comprise persons and corporate bodies of the following status:

(*a*) Ordinary Members, who shall be the signatories of the Memorandum of Association and those British subjects carrying on business or otherwise engaged in the Gas Industry, and those British Corporations carrying on business as aforesaid, who shall be admitted as members of the Association.

(*b*) Associate Members, who shall be such members of any class of The Institution of Gas Engineers or other scientific workers or persons engaged in or connected with the Gas Industry or likely to assist in its development as shall be so admitted to membership, provided always that no person shall be eligible for Associate Membership who is employed by a Corporation or firm eligible for Ordinary Membership either itself or through a representative but which or a representative of which has not been admitted as an Ordinary Member.

(*c*) Delegate Members, being delegates of other associations established for kindred purposes.

(*d*) Honorary Members, being persons whether entitled or not to become Members under the above provisions and nominated for membership by the Council for special services or for special cause, and elected at a General Meeting.

The Council of The Institution of Gas Engineers having agreed to give financial support from its Special Purposes Fund to the Gas Research Board, it follows that any incorporated Gas Undertaking which now subscribes to the funds of the National Bodies will become eligible without further payment for Ordinary Membership and, if elected, will be entitled to nominate a person to act as its representative, subject to certain safeguards. British Corporations engaged in the manufacture of plant and appliances for the Gas Industry will also be eligible for Ordinary Membership, while firms or other unincorporated associations similarly engaged will be eligible to nominate one of their members for membership on their behalf. The class of Associate Member will permit individuals, who may not be nominated as the representative of a member corporation or of a firm, to become associated with the work of the Gas Research Board.

Research Committees

Amongst other matters of an administrative nature, to which the Council has had to give consideration, is the position of the Joint Committees conducting research on behalf of the Gas Industry and reporting to the former Research Executive Committee of The Institution of Gas Engineers.

The Committee generally referred to as the Joint Research Committee has previously been a Joint Committee of The Institution of Gas Engineers and Leeds University, but, with the consent of the Councils of the Institution and of the University, it has been agreed that in future it shall be a Joint Research Committee of the Gas Research Board and Leeds University. The position of the Research Chemists and Assistants attached to this Committee has been reviewed and it has been decided that Dr. F. J. Dent and Dr. A. Key should be Research Chemists of the Gas Research Board seconded to the Joint Research Committee for carrying out the work of that Committee, while the other members of the Research Staff should remain as Research Staff to the Joint Research Committee. The Gas Research Board would accept all such responsibilities towards the Research Staff as had previously been borne by The Institution of Gas Engineers.

The Refractory Materials Joint Committee has previously been a Joint Committee of The Institution of Gas Engineers, the Society of British Gas Industries and the British Refractories Research Association. The Councils of these respective bodies have agreed that the Committee shall in future be a Joint Committee of the Gas Research Board and the British Refractories Research Association.

The Council desires to thank all those who serve on its Research Committees or who otherwise assist in the investigations of the Board. Such service and assistance are particularly appreciated under existing circumstances, when there are so many other urgent calls on time and energy.

Information Bureau

A feature of the Gas Research Board which, it is hoped, will in time be of great assistance to the Industry, is a Bureau of Information. It is felt that there has not hitherto existed within the Gas Industry a Central Bureau through which technical information touching upon the multifarious interests of the Gas Industry can be collected together and made readily accessible to those who may wish to apply the information in their work. Some of the larger Undertakings and Firms, both on the supply and manufacturing side, have made their own arrangements to provide such facilities for their staff and in some instances have generously extended these facilities to others outside their own organization. The co-operation of all such private bureaux is sought and has, indeed, in several instances, been freely offered already. It is clear that the establishment of such a Bureau involves a great deal of work, and even without the interruption of war it would have been some time before the Bureau could have functioned with full efficiency. In existing circumstances, the project becomes even more difficult but, as with other sections of this work, the Council feels that although progress may be slower than in normal times, the prosecution of all these projects should continue.

Presentation and Discussion of Results of Investigations

It is intended that all members of the Gas Research Board shall receive from time to time confidential reports of the progress of the investigations conducted by the Board. It has, however, been indicated on previous occasions that the establishment of the Gas Research Board would not interfere with the customary and important function known as the Autumn Research Meeting of The Institution of Gas Engineers, and the Council of the Institution has agreed that reports of the results of researches conducted by the Gas Research Board and other Communications submitted with the approval of the Council of the Board for publication, might form one of the bases for this annual Research Meeting, the proceedings at such meetings being recorded in the Transactions of The Institution of Gas Engineers. The same Autumn Research Meeting would provide an opportunity for the Council of the Gas Research Board to meet and report to the members of the Board and receive their criticisms and suggestions on past and future work. It is particularly regrettable that the first occasion upon which such a meeting should have been held has perforce to be missed owing to the difficulties of the present time.

Policy and Programme

Within two months from the date of its appointment, the Council of the Gas Research Board found itself faced with the unforeseen necessity of deciding its policy and programme of work under war conditions. It had been hoped that this newly-formed Research Board would pursue a wholly constructive policy and the fact that its first discussions should be devoted to the destructive business of war was profoundly disappointing. In the changed circumstances there was no question that the duty of the Council was to seek by every means in its power to assist in the general war effort. It was apparent that there would be numerous technical problems arising from the change-over to war conditions and the solution of these problems was undoubtedly an appropriate field of work for the Gas Research Board.

At the same time, it was obviously important that the fundamental constructive work of the Gas Research Board should not be allowed to become obscured by demands which, however pressing, could only be of a temporary nature. Modern warfare demands the mobilization of every resource that a nation possesses and although the origin is entirely regrettable, it does compel a stocktaking of national assets. In time of peace, when these assets might be used to better advantage, such stocktaking is too frequently neglected. At the present time it is impossible to forecast what may be the position of the Gas Industry at the conclusion of the war, but it does appear certain that with the reconstruction that will inevitably be necessary, the need for a reasoned fuel policy for the nation will be recognized. It is not disputed that the Gas Industry plays a major part in the present utilization of fuel, but the question will one day arise as to the part which the Gas Industry should play in a comprehensive national fuel scheme, whether it should be its present part, or less, or more. If change should be necessary, in what direction should that change be?

The economic situation of the country after the war may demand drastic revision of what has hitherto been considered possible and desirable. It may be that the nation will find

that it is unable to live so largely on imported goods, and that it may be forced to make better use of those goods which can be produced at home. Here indeed are problems to which a speedy answer is in the nature of things not possible, but they are the type of question upon which the long distance programme of the Gas Research Board must be framed. Such fundamental issues have not been forgotten even though the urgent demands of these last few months have made it impossible to see the immediate future for more than the shortest distance ahead.

Joint Research Committee of the Gas Research Board and Leeds University

The membership of the Joint Research Committee is:

Nominees of the Gas Research Board: Harold C. Smith, J.P. (*Chairman*); E. V. Evans, O.B.E.; Stephen Lacey, B.Sc.

Nominees of the University of Leeds: Prof. W. T. David, M.A., Sc.D., D.Sc.; H. J. Hodsman, M.B.E., M.Sc.; Prof. John W. Cobb, C.B.E., B.Sc.; Prof. D. T. A. Townend, D.Sc., Ph.D., D.I.C. (*Honorary Secretary*).

Co-opted: Charles F. Botley; J. E. Davis; Harold Hartley, D.Sc.; F. O. Hawes; H. Hollings, D.Sc.; C. A. Masterman, M.A.; C. S. Shapley.

The work of the Joint Research Committee on the complete gasification of coal has been continued on substantially the same lines as those laid down when this work was commenced, although the possibility of utilizing methane as a war-time fuel for motor traction has caused special attention to be given to the possibility of devising a process which could be put into operation quickly, should the demand for methane for this purpose exceed the available supplies. This modification of the programme has not meant any serious departure from the lines originally planned, for it has been clear from the outset that it would be necessary to include a study of the possibilities and limitations of catalysts in the synthesis of methane. This aspect of the work has been and is being studied in the closest co-operation with the Fuel Research Board through the Joint Committee on Complete Gasification under Pressure and its Methane Panel, and although it is considered not to be in the national interest to publish detailed results of the investigations at the present time, it may be said that the difficulties which had hitherto hindered the development of this process are becoming far more clearly understood and controllable.

The well-known difficulties of the catalytic process are the deposition of carbon on the catalyst, the progressive loss of activity in the catalyst, due to what may be termed "ageing", and the poisoning of the catalyst by sulphur compounds. Each of these three problems has been attacked with considerable success by the chemists engaged on this work and they no longer appear as the formidable obstacles which they have been hitherto. At the same time, the strongly exothermic nature of the reaction tends to make the preparation of methane in this way a process of low thermal efficiency. It is probable that a means will be found of employing this exothermic heat usefully and in such a way that the overall thermal efficiency is not reduced. This aspect has received considerable attention.

The study of the possibilities of liquefied methane as a fuel for internal combustion engines has shown considerable development and the closest contact is being maintained with the work which, under the direction of Prof. A. C. G. Egerton, M.A., Sec.R.S., is covering the preparation and utilization of this fuel.

The production of methane by the gasification of coal in hydrogen under pressure has not lost its interest, but circumstances arising from the war have made it impossible so far to proceed with the large-scale experiments that had been planned in co-operation with the Fuel Research Board. There is some possibility that other arrangements for the continuance of this work may be available and the Joint Research Committee will take advantage of any and every opportunity that offers itself.

Sub-Committee on Combustion Characteristics of Town Gas

The Sub-Committee has continued to meet at intervals and interest in this subject is still active, although the Joint Research Committee is not at the moment sponsoring any experimental work in this matter.

Refractory Materials Joint Committee of the Gas Research Board and the British Refractories Research Association

The membership of the Committee is:

Nominees of the Gas Research Board: T. F. E. Rhead, M.Sc. (*Chairman*); T. Allen; F. H. Brooke; John L. Butler, M.B.E.; A. Edwards; P. C. Gardiner; W. J. Gardner; W. T. Gardner; W. Grogono; C. R. F. Threlfall, M.C., M.A.

Nominees of the British Refractories Research Association: Lieut.-Col. C. W. Thomas; Frank West.

Ex officio: A. T. Green (Director of Research, British Refractories Research Association).

Co-opted: F. H. Clews, M.Sc.; H. G. Colman, D.Sc., Ph.D.

The Committee has continued to meet regularly during the year and its 31st Report, published separately (*Communication No.* 2), contains the records of the following investigations:

The work on refractory insulating materials commenced last year has been continued and developed, the present Report containing five Papers dealing with this subject. Encouraging results have been obtained from a brick made from fireclay and pulverized coal. Such a gradated brick has a dense slag-resistant face backed by porous insulating material. The laboratory test shows that slag resistance, shrinkage on reheating, refractoriness-under-load, and cold crushing strength, are better than those of ordinary commercial insulating bricks and that the heat capacity and transmission are about half as great as ordinary firebrick though 1½ times that of the best commercial insulating bricks.

In the work on the action of alkalies on refractory materials, the disruptive force set up by the action of alkali chloride vapours at 1,000°C. has been demonstrated; a small block of aluminous fireclay subjected to the action of potassium chloride at 1,000°C. cracked very badly after 15 hr. through the expansion of the interior. Further work with sodium and potassium chloride, sulphates, and carbonates with silica and fireclay material shows that the action on silica material results in a marked decrease in strength brought about by fluxing. The action of sodium salts on fireclay material causes softening.

A series of experiments on the action of chlorine on refractory materials has been commenced in which the material is subjected to the action of chlorine for 2 hr. at 1,000°C. Owing to the formation of volatile chlorides of iron, magnesium, calcium and aluminium, loss in weight occurs. A blue brick clay was strongly attacked but silica, sillimanite and aluminous firebricks only slightly.

A new method for the rapid assessment of the disintegrating action of carbon monoxide has been developed, depending on the determination of the amount of carbon dioxide formed after passage of CO at the rate of 1 litre per hr. over 75 g. of crushed sample at 450°C. If the amount of carbon dioxide formed after 4 hr. represents 0·13 per cent of the weight of the sample, the material should be regarded as liable to disintegration by the action of carbon monoxide.

Specifications Sub-Committee

The Sub-Committee has continued with the revision of the Standard Specifications for Refractory Materials for Gas Works, the last Edition of which was issued by The Institution of Gas Engineers on 31st July, 1934. Co-operative trials were carried out by members of the Sub-Committee on the maintained temperature refractoriness-under-load test. In the first trial, the percentage deformation varied from 0·48 to 1·50 per cent and in the second from 1·50 per cent to zero. In order to determine whether this variation was due to lack of uniformity in the bricks, further experiments were carried out on samples from the same single block of fireclay. The results for the percentage deformation varied from 3·02 to 0·67 per cent. A relation between the heat work and the observed deformation was apparent and it was concluded that the material was sensitive to variations in thermal treatment at about 1,300°C. Lack of concordance between the different pyrometers accounts for the variations observed. In its present form, therefore, the test is unsuitable as a standard method for general use.

Other Investigations

(a) *Domestic Heating and Ventilation*

The Domestic Heating Committee of The Institution of Gas Engineers has referred technical problems which require investigation to the Gas Research Board for its attention. The Council has approved a grant for further work on the ventilation of rooms and has reserved a sum of money for experiments on comfort conditions in rooms heated by various fuels and in various ways. The commencement of work on this matter has been deferred for the present in view of the appointment of a Committee by the Medical Research Council to consider the question of comfort conditions in all its aspects, but the Council of the Gas Research Board is in contact with this Committee and is prepared to give it all the assistance that may be needed.

(b) *Noises of Gas Burners*

The investigation by the National Physical Laboratory for the Gas Research Board of the cause of noise in gas burners has made considerable progress and a Memorandum based upon an interim report of the National Physical Laboratory has been prepared and is published separately (*Communication No.* 3).

(c) *Wind Stresses on Spirally-Guided Gasholders*

The other investigation which the National Physical Laboratory is carrying out for the Board, namely, the study of the stresses imposed by wind upon the structure of spirally-guided gasholders, has also made progress, although somewhat slower than would have been the case in normal time. Wind pressure distribution over models and the wind resistance and lift forces on the inner and outer lifts of the models have been determined for a number of air speeds. The results are being analysed with a view to ascertaining the extent to which the pressure distributions obtained agree with force measurement in order to compute the effect of surface friction.

(d) *Industrial Furnaces*

The programme of work which was commenced at the City and Guilds College, London, for the joint Industrial Furnaces Research Committee and under the guidance of Prof. C. H. Lander, C.B.E., D.Sc., was first restricted to meet war conditions. At a later date it was regrettably necessary to suspend this work owing to the staff being required for more pressing work arising out of the war. The subject of heat transfer formed the major part of this work, in which the Board co-operated.

(e) *Luminescence Phenomena*

It will be recalled that the Research Executive Committee was invited by the Arthur Duckham Memorial Fund Committee to suggest a suitable subject for investigation by the Second Arthur Duckham Research Fellow, and in response to this invitation proposed that work should be commenced on a study of the phenomenon of luminescence, particularly as this phenomenon arises in the presence of gas flames in contact with heated bodies. The Gas Research Board has provided specialized apparatus to assist in the prosecution of this work and it may be said that preliminary results of great interest have been obtained already.

(f) *Benzole and Toluene*

Shortly after the outbreak of the war, the Secretary, on the instruction of the Council, undertook a survey of the existing plants in the Gas Industry for benzole recovery and on representations from the Ministry of Supply efforts were made to induce some of the Gas Undertakings then not carrying out benzole recovery to commence operating this process. The Secretary and Acting Director of Research was also appointed as the representative of the Gas Industry on the Toluene Advisory Committee of the Ministry of Supply. The responsibility for co-ordinating matters relating to benzole recovery within the Gas Industry was subsequently taken over by an *ad hoc* Committee, appointed by the Mines Department, upon which the Gas Industry is represented.

(g) *Coke for Portable Gas Producers*

The development of traction producers by the Fuel Research Station and others made it necessary to survey the possible sources and means of production of the special fuel needed for these producers. The Gas Research Board was entrusted by the Mines Department with the task of ascertaining the amount of carbonizing plant available in the country for the production of specially reactive coke and the methods to be adopted in operating horizontal retorts and continuous or intermittent vertical retorts to yield a satisfactory fuel. This work has been undertaken in co-operation with the Fuel Research Board and the British Coal Utilization Research Association, and the thanks of the Council are due to all those throughout the country who have freely given their assistance in this matter. This work is still in progress and developments from it may be of permanent interest after the end of the war.

(h) *Alternative Fuels*

The Council of the Gas Research Board was consulted by the Alternative Fuels Committee of the Mines Department as to the ways in which the Gas Industry could assist in the general question of the replacement of imported fuels and the more efficient utilization of home-produced fuel. A Confidential Memorandum on this matter, showing the part already played by the Gas Industry and making suggestions for directions in which the resources of the Gas Industry could be further employed, was submitted to the Alternative Fuels Committee early in 1940.

(j) *Hydrogen*

From time to time the Gas Research Board has been consulted by Departments of the Air Ministry on various aspects of hydrogen supply and the use of coal gas for the inflation of balloons. Some recommendations on technical details have been accepted and offers have been made of further assistance, particularly as regards the production of hydrogen.

(k) *Gas Purification Material*

With the cessation of supplies of purifying material from the Low Countries, the Gas Research Board and The Institution of Gas Engineers were consulted by the Board of Trade as to the requirements of the Gas Industry and alternative sources of supply of suitably active purifying material. Information regarding such alternative sources had previously been collected by the Secretary for the guidance of gas engineers who might be in need of supplies.

Conclusion

In conclusion it may be said that the Council does not regard this 1st Report with satisfaction. The outbreak of war has diverted the attention of members of the Council to work of more pressing urgency than the building up of a broader research organization and this in itself has been a great disappointment to them as individuals. If there is any compensation to be found for the diversion of energies from the work which the Council wished to undertake, it is in the fact that to some small extent, at least, the Gas Research Board has been able to assist Government Departments in many directions at a time of national necessity.

Gloucester Gas Company

Success of Profit Sharing Scheme

The 240 members of the Gloucester Gas Light Company's Profit Sharing and Saving Scheme have £19,916 standing to their credit, an average of approximately £83 per member. These and other gratifying figures were given at the annual general meeting of members held at the Gas-Works, Hempsted, on Nov. 21.

Mr. J. Morgan Matthews, who presided, drew attention to the fact that the Directors had declared a bonus of 3½% for the year. Normally, the rules provided that an average bonus of 2¼% should be paid, but the Directors felt that the employees should reap some extra benefit during the critical period through which the country was passing. The total bonus for the year to be divided among the members was £1,181 compared with £1,201 in the previous year.

Since the scheme started the total bonus received by members amounted to £30,909, and the total interest paid to members was £12,407. These figures indicated the success of the Scheme.

Mr. Leslie Boyce, the City Member, seconding the adoption of the report and statement of accounts, spoke of profit sharing as an expression of the employers' desire to do their best for their employees by giving them a share in the prosperity of the Company, thereby securing their personal interest. Such a scheme, he said, was particularly appropriate in relation to a public utility company having a monopoly of the supply of the commodity which it manufactured, but it was not so appropriate in some other industrial concerns.

The report and statement of accounts were adopted, and spokesmen on behalf of the employees expressed appreciation of the action of the Directors in increasing the bonus.

MEASUREMENT OF PRESSURES DEVELOPED DURING THE CARBONIZATION OF COAL*

By CHARLES C. RUSSELL,

Koppers Company, Engineering and Construction Division, Kearny, N.J.

PRESSURES developed by coal during the coking process have been responsible for serious trouble to many companies that operate or build by-product coke ovens. The insidious nature of this trouble is indicated by the fact that oven operators, unless they have ascertained the characteristics of the coals they use, cannot determine the existence of dangerous pressures until after the damage has been done.

The following paper presents a highly certain method for the measurement of the pressures developed during the carbonization of coal—a method that is the culmination of many years of work on the problem in which a number of methods for the purpose were investigated and used. While actual pressures found may appear to be small when expressed in pounds per square inch, the number of square inches in each oven wall is so large that the total pressure on the oven wall becomes an enormous load.

Swelling or Expansion

" The coal used . . . will swell during the process of coking to such an extent as to raise the tops from the ovens and push the doors out on each end, though solidly clamped with steel bars. . . ."(1) That statement was written in 1906. Korten's(2) paper, published in 1920, is of interest. Many papers were written by German investigators. When Altieri(3) presented his first paper before the American Gas Association in 1935, it aroused very active interest among American coal technologists. In 1938 the interest had grown to such an extent that a symposium on the subject was held at the Production Conference of the American Gas Association.

It is a curious fact that the term " coal expansion " has been widely accepted in the United States as descriptive of the phenomenon in question. This phenomenon, however, concerns the development of pressures within the coal during carbonization that are exerted against the coke oven walls. An "expanding coal " is considered to be one that will develop sufficient pressure during coking to weaken, distort or otherwise seriously damage the walls.

It should be noted that the terms " coal expansion " and " expanding coal " do not carry any implication of pressure development, but rather suggest increase in dimensions. Undoubtedly this use of terms has come from laboratory studies of the swelling of coal. Work on this subject has been carried out over a period of years, particularly by English technologists, and has been used principally to determine the relative "coking properties " of various coals and also as a means of separating coals into various ranks. While Brown(4) states that there seems to be no relation between " expansion " and " free swelling," undoubtedly the fact that rapid gas evolution begins during the heating of coal in about the same temperature range as the coal fuses accounts for both of the behaviours studied.

Whether a coal" swells " or " expands " during carbonization appears to be a matter of the container in which it is carbonized and the manner in which heat is applied. If there is ample free space, the coal swells up in accordance with its particular characteristics, but if the coal is carbonized in a restricted volume, *the effort of resisting the swelling is expressed as a pressure*. The degree of swelling or pressure developed, however, is quite dependent on the fluidity attained during carbonization and also on the rate of evolution of volatile products.(5) These factors are functions of the rank of the coal, its composition, and to some degree the rate at which heat is applied.

In a by-product coke oven, the coal is contained between two vertical walls, usually about 18 in. apart, and the charge in the newer ovens is at least 12 ft. high. Because the ovens are about 40 ft. long, the doors at either end play a relatively minor role in retaining the coal. With the exception of the coal at the immediate top of the charge, all of the coal within the coke oven is in some measure restricted in volume. The closer to the bottom, the greater is the restriction. It has been shown(6) that granulated material in a narrow bin does not behave like a fluid, and consequently the pressure on any plane below the top of the charge is not equivalent to the weight of the superincumbent coal. However, during carbonization, the effort exerted by the coal in a given position to increase in volume is at least equivalent to the weight of the coal above it.

The degree of packing, expressed as bulk density, has been found by all investigators to be an important function of the amount of swelling or pressure developed. The denser the charge of coal, the greater will be the amount of swelling or pressure developed during carbonization. Auvil and Davis(7) have shown that the increase (or decrease) in volume of a given coal carbonized under specified conditions is directly related to the expansion of the *solid* coal. On this basis they have presented a method of calculation whereby the results obtained at one bulk density can be calculated to any other bulk density.

Koppers and Jenkner (10) describe a large test oven in which coal can be carbonized under substantially the same conditions as exist in full-scale ovens. One of the walls of this oven is entirely separate from the rest of the oven, and is supported on wheels. Any movement or pressure developed by the coal in the oven chamber is transmitted to this movable wall. A hydraulic cylinder is attached to the movable wall, so that the pressure of the coal against the wall may be measured by balancing it with the pressure in the cylinder. A large number of determinations were made with this apparatus. One of the principal, and most important, findings thus obtained was that the pressure developed during the carbonization of the coal rises rapidly and reaches a maximum when the two plastic zones meet at the centre of the oven. After the peak of pressure is obtained, the pressure drops precipitately because of the shrinkage of coke formed.

This pressure peak is not shown by any other apparatus described in the literature except that described by Ulrich. Certainly no laboratory procedure produces results that show this phenomenon. In some cases this peak is as much as five times that which was obtained during the earlier part of the coking period. It will be shown later that it is impossible to reproduce this behaviour in tests where the coal is heated from one side. And it will also be shown that where coal is heated from two sides and volume increase is measured only a very slight indication of this peak can be obtained. The description of this apparatus and the results obtained therefrom were published in 1931, and it is strange that this important point should have been either ignored or overlooked in all the published accounts of work on coal expansion since that time.

Test Oven with Movable Wall

Some time ago Koppers Company designed and erected a test oven based on the principle of that described by Koppers and Jenkner. The general arrangement of this apparatus is shown in fig. 1. The oven chamber itself has a capacity of about 400 lb. of coal. It is 12 in. wide, 42 in. high, and 28 in. long inside the doors. Each wall of the oven has an area of about 1,000 sq.in. The heating flues and the face of the oven walls are constructed of standard 9-in. Alcor brick, which has the mechanical properties of silica brick without having the crystallization changes that affect the expansion of silica brick.

This brick was selected so that the oven could be shut down or started up in a relatively short time. The oven is completely insulated with one course of Sil-O-Cel brick and the outside cover is constructed of first-quality firebrick. The roof of the oven is suspended from the top I-beams of the strong back, so that the movable wall will move without contact with the top. The movable wall is constructed on a steel carriage, which is equipped with roller-bearing rollers that rest on 1¾-in. cold-rolled round steel, the wheels being grooved so that they have the smallest possible contact with the rails to reduce friction. The entire oven sits within a strong back constructed of 8-in. I-beams and channels.

A lever system with a 7 : 1 ratio mounted on this strong back as indicated in fig. 1 is used for the transmission of the pressure

* Extracts reprinted from Technical Publication 1118 of the American Institute o Mining and Metallurgical Engineers.

or movement to the mechanism for measurement. Weights attached to the movable wall through cables as shown counterbalance the weight of these levers. Instead of the hydraulic cylinder used by Kopper and Jenkner for measuring the pressure developed, a simple mechanical principle has been applied, which is far less expensive and without doubt as sensitive as the hydraulic cylinder. It has the additional advantage that the equipment required is available in practically all laboratories.

The principle involves the placing of a heavy weight (1,200 lb.) on a rigid carriage on a fairly sensitive platform scale. The levers as shown are rigidly connected to this weight through two turnbuckles. Before the test is begun the weight of the load is accurately determined, and then carefully connected to the levers, so that the pull is not more than 20 lb. After the coal is charged

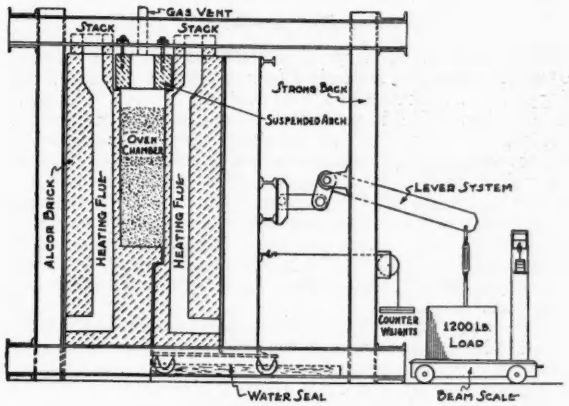


FIG. 1.—*Oven with Movable Wall.*

into the oven, any pressure developed is transmitted to the wall, thence to the levers and to the load. As the pressure increases, the load on the platform scale is reduced proportionately, and this is determined by weighing the load at frequent intervals. In this way a continuous record of the course of pressure developed during carbonization of a test charge can be obtained. Substantially no movement of the movable wall takes place as long as the pressure in the oven is less than the effort required to lift the weight. What movement occurs is determined by a gauge accurate to 0.001 in.

The oven has only one door, which is lined with 9 in. of brick for insulation. The back of the oven is an integral part of the oven structure, and contains a carborundum block 5 in. high having 13 holes spaced 1 in. apart, centre to centre, that lead into the oven chamber. These are used for the introduction of thermocouples to measure the temperature progression at 1-in. intervals throughout the width of the oven. In order to prevent erroneous temperature readings due to transmission of heat through the steel protecting tubes, the thermocouple wells are staggered in length. The centre couple is the longest, and each couple proceeding from the centre toward each wall is 1½ in. shorter than its adjacent couple.

The oven is heated with coke oven gas conducted to the flues through open pipe burners. The gas main to the movable wall is of flexible steel tubing, to avoid strain. This also allows the movable wall to be moved out for cleaning. Temperatures of the heating flues are obtained by means of an optical pyrometer at three locations in each wall.

Coal is charged into the oven from a hopper 6 ft. above the top of the oven, through a pipe, into a hole in the centre of the suspended top. After charging and levelling, the pipe is removed and a gas vent installed in its place. The charge is coked until the centre thermocouple indicates a temperature of about 600°C. At that temperature the coal has passed through its plastic stage and has become solidified coke. It has also been found that above that temperature no further increase in pressure is obtained. With low-volatile coals that produce high pressures, the maximum pressure has been reached below that temperature and the rapid pressure decrease is well in progress. At the end of the coking period, the coke is raked out of the oven by hand.

In the first group of tests made with this oven the wall was allowed to move against a pressure of 2 lb. per sq.in. This pressure was exerted by hanging weights equivalent to that pressure on the lever arms, and in that case the levers were not connected to the 1,200-lb. load described above. The oven was referred to in an earlier paper([12]), but few data were at hand when that paper was presented. Fig. 2, curve I, shows the movement of the wall found for a low-volatile Beckley Seam coal. The movement is expressed as percentage of the original oven width. Particular note should be made of the upper end of the curve, where the rate of movement increases rapidly for a 15-min. period, and then drops off slightly. Curve II shows the data obtained when testing this coal in the Altieri type A apparatus. Data of each are shown in Table I.

TABLE I.—*Expansion Tests of Low-volatile Coal from the Beckley Seam.**

Oven.	Maximum Linear Expansion, Percentage of Original Width.	Bulk Density of Coal as Tested, lb. per Cu.ft.	Load on Coal, lb. per Sq.in.	Original Thickness of Coal, In.	Temperature of Heating Wall, End of Test, Deg. C.
Koppers movable-wall oven	8.8	54.0	2	12	971
Altieri type A	12.6	55.5	2	6	934

These data indicate that the two methods of testing this coal produce results of comparable magnitude. By calculation of the results from the Altieri type A to 54.0 lb. per cu.ft., as described by Auvil and Davis([7]), the percentage of maximum expansion is found to be 9.6%, which is within 1% of that found in the movable wall oven. Sufficient data were not obtained to show that such accuracy can be sustained.

When the movable-wall oven was rearranged to make tests wherein the pressure developed during carbonization was determined, the first coal investigated was also a low-volatile coal from the Beckley Seam comparable to that of Table I. Fig. 3, curve I, shows the data thus obtained. The curve indicates data that are comparable in general with those described by Koppers and Jenkner.([8]) Near the end of the coking period a high peak of pressure is found, which occurs at the time of the junction of the two plastic zones.

In order to prove directly that it was the juncture of plastic zones that caused the sudden increase in pressure near the end of the coking period, the oven was arranged so that it was heated from the movable-wall side. By so doing, the coking proceeded from one wall and there was only one plastic zone. To reduce the coking time to be comparable with that of coking from two walls, one-half the oven was filled solidly with brick. This made a coal space one-half that of the normal oven. In order to

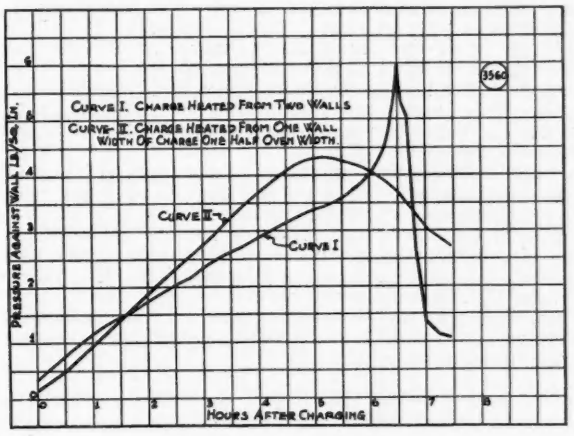

3560
CURVE I. CHARGE HEATED FROM TWO WALLS
CURVE II. CHARGE HEATED FROM ONE WALL WIDTH OF CHARGE ONE HALF OVEN WIDTH
CURVE II
CURVE I
PRESSURE AGAINST WALL LB./SQ.IN.
HOURS AFTER CHARGING

FIG. 2.—*Expansion Tests, Low-volatile Coal from Beckley Seam.*

prevent the cold wall from absorbing heat from the hot wall, the coal space was packed with Sil-O-Cel bricks until just before charging the coal.

When the test was ready to be made, the Sil-O-Cel bricks were withdrawn, the door was put back and luted and the coal charged as soon after as possible. Fig. 3, curve II, shows the data thus obtained. In this test there is no indication of any pressure peak near the end of the coking period. In contrast, the pressure increases at a rate fairly comparable to that in the early part of the coking period, where the coal is heated from two sides, and then more gradually decreases. This curve has much the same general shape as those obtained in test apparatus where the volume change is measured and where the coal is heated from one side.

* See Fig. 2.

These tests prove quite conclusively that when two plastic zones are present a high peak of pressure is developed when coking low-volatile coal in an oven heated from two sides. They also indicate that where coal is heated from one side only, giving rise to one plastic zone, no such peak of pressure occurs. The methods of testing now in use in the United States all heat coal from one side only. Under these conditions it is impossible to produce this pressure peak. Furthermore, these same methods all measure expansion of the coal in terms of increase in dimension of the coal charge.

Fig. 2, in which is shown the measurement of the increase in width of the movable-wall oven, also shows the increase in rate of change of width that occurs near the end of the coking period.

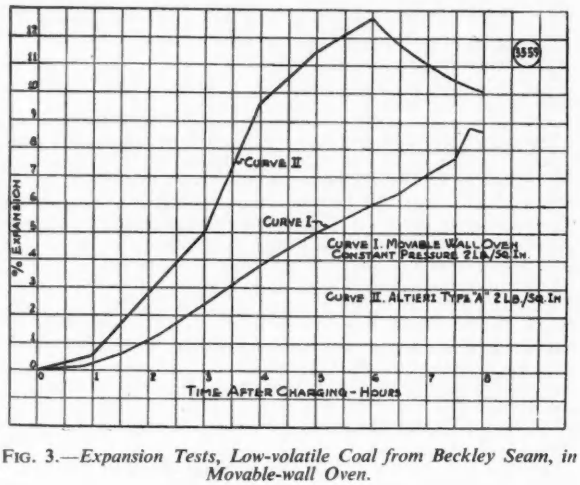

3559
% EXPANSION
CURVE II
CURVE I
CURVE I. MOVABLE WALL OVEN CONSTANT PRESSURE 2 LB/SQ.IN.
CURVE II. ALTIERI TYPE "A" 2 LB/SQ.IN
TIME AFTER CHARGING - HOURS

FIG. 3.—*Expansion Tests, Low-volatile Coal from Beckley Seam, in Movable-wall Oven.*

The total change in width during this period of increased rate of change of width amounts to only 0.13 in., or about 13% of the total change in width. On the other hand, the pressure peak is as much as 40% higher than the pressure just prior to the beginning of the rapid rise.

In the case of borderline coals, the knowledge of the existence of this pressure becomes far more important than for coals that are known to be dangerous to coke oven walls. The present methods of testing use a load of about 2 lb. per sq.in. While this may be an arbitrary value, the interpretation of the test results made on that basis presumes that a coal is dangerous to coke ovens that increases in volume under the load of 2 lb. per sq.in. This literally means that during the carbonization of the coal in the test apparatus pressures greater than 2 lb. per sq.in. are produced.

With borderline coals that are tested under that load and heated from one side, pressures of just under 2 lb. per sq.in. may be developed, in which case no increase in volume can occur and the final value obtained may indicate a slight shrinkage. However, because the coal is heated from one side, even the small rapid increase cannot be found near the end of the coking period because of the presence of only one plastic zone. Consequently the pressure peak of more than 2 lb. per sq.in. that would occur when the coal is coked in a full-scale oven is not detected by the present methods of testing.

Borderline Example

Fig. 4 shows an example of the situation described above. Curve I shows the results obtained with the Altieri type A apparatus, and indicates that the coal would be safe to use. In curve II the pressure developed during coking is shown. It will be noted that 1½ hr. after charging the pressure reached 1.75 lb. per sq.in., and that it remained consistently at that value until very near the end of the coking period. At that time the pressure increased rapidly to 4 lb. per sq.in., after which it dropped rapidly. This condition must exist in full-scale ovens, for the walls are rigidly fixed and there is no possibility that a volume change may relieve this pressure. It should also be considered that in this case the pressure was developed in a charge only 36 in. high, whereas in full-scale ovens the charge is approximately 144 in. high.

High-volatile coals and various mixtures used regularly in a number of coke oven plants have been tested with this oven. None of the high-volatile coals have been found to produce a pressure of more than 1 lb. per sq.in. A few mixtures of high-volatile and low-volatile coals that are regularly used produce pressures as high as 1.5 lb. per sq.in. It is also interesting to note that the coals that produce pressures under 1.5 lb. per sq.in. generally do not exhibit a peak of pressure near the end of the coking period similar to that obtained with the low-volatile expanding coals. Probably this can be explained on the basis that these coals become quite fluid, so that even with the juncture of the two plastic zones the fluidity of the coal is high enough to permit the escape of gas without the creation of high pressures. In the relatively small amount of work that has been done to date on the measurement of fluidity of coal by the Gieseler method, it has been found that the maximum fluidity of a number of low-volatile coals is of the order of 10 units or less, whereas the high-volatile coals are in a range from 1,000 to 3,000 units. This tends to substantiate the statements just made.

Density Important

Bulk density of the charge to be tested has been found to be an extremely important factor in affecting the pressure developed. Koppers and Jenkner[10] have pointed this out, and it has been the experience of all investigators, no matter what method was studied. To make the bulk density of the test charge in the movable-wall oven comparable to that found in full-scale ovens is a difficult problem to solve. In the first place, the exact bulk density of coal in the full-scale ovens is difficult to estimate. As mentioned earlier, attempts have been made to determine this in a full-sized oven constructed of wood, but some data are at hand to indicate that the charging of coal into a cold oven is not comparable to charging it into a regular hot coke oven of the same dimensions.

The wooden oven method has shown that there is considerable variation in a coal charge. It appears reasonable, however, to make the expansion tests at the highest bulk density that may be presumed to exist in the coke oven. Since bone-dry coal appears to have a fairly uniform bulk density of about 54 lb. per cu.ft., it is believed that that figure should be the minimum value for use in test procedure. To attain this value in the movable-wall oven tests, it has been found that air-dried coal of less than 2% moisture is quite satisfactory.

The description of this movable-wall oven and the presentation of results have been made to demonstrate some of the fundamental factors that must be considered in designing satisfactory testing equipment for the determination of coal expansion. No claim is made that the apparatus described should be adopted as a standard procedure for testing, but any apparatus selected for standard procedure must embody the principles that have been described.

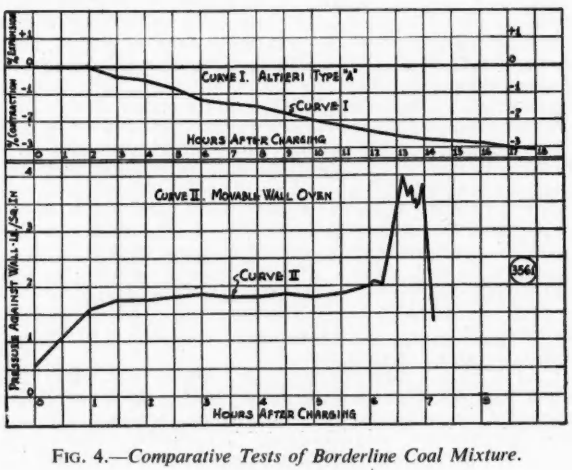


FIG. 4.—*Comparative Tests of Borderline Coal Mixture.*

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EXTRACTION OF A BITUMINOUS COAL*

INFLUENCE OF THE NATURE OF SOLVENTS

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TWO earlier papers ([2], [3]) from this laboratory on the extraction of a Pittsburgh seam coal with organic solvents described work on a study of the effect of time, temperature, coal particle size, and vapour heating on yield of extract, and showed that the nature of the solvent is of great importance in determining yield. The present paper treats this latter aspect of the problem of extraction more extensively. Many new solvents have been tried, and several have good solvent properties. At temperatures from 150° to 300°C. it has been found that the effectiveness of a given solvent is, as a first approximation, directly proportional to its internal pressure.

Most investigators have used extraction with a single solvent as a tool in studying coal properties, degree of oxidation, &c. Only a few workers who have used more than one solvent in extraction studies have considered the relation between the physical properties of the solvent and the yield of extract obtained. Kreulen([6]) made comparisons of surface tension with yield of extract on several solvents tested by himself and other workers. However, Kreulen was concerned more with the resolution of products obtained by extraction with a single solvent, by use of other liquids of different surface tension, than with the effect of the nature of the solvent on yield at high temperatures. Nellensteyn and Roodenburg([10]) studied the relation between surface tension, temperature, and solubility of asphaltic bitumens. Kuznetzov([7]), working on Russian coals, used a large number of solvents and pointed out several relations between yield and chemical nature of the solvent. In the present study fifty-seven solvents were studied at one temperature, 200°C. ; six of them were studied at 150°, five at 250°, and twelve at 300°C. For simplicity only one coal was used in this work—a Pittsburgh seam coal from the Edenborn mine in Fayette County, Penna.([2]).

Apparatus and Procedure

The extractions were carried out in small stainless steel bombs (fig. 1). They were made from 1.5 in. (3.8 cm.) double-strength seamless steel tubing, spun down and welded at one end with a simple copper gasket closure at the head. A pressure connexion in the head allowed release of gas which might be formed. The capacity of each bomb was slightly over 300 c.c. (18.3 cu.in.).

The rotating heater for the bombs consisted of a cylindrical aluminium casting drilled from end to end with seven holes which the bombs occupied. This construction allowed the use of fourteen bombs at a time, seven in each end. The aluminium block was covered with a non-uniformly wound heating wire, heavily lagged and enclosed in a sheet metal housing. End plates, larger in diameter than the housing, served as supports for rotating the heater. Doors were provided at both ends and were likewise heavily lagged. The entire heater was supported by the end plates on four small pulleys, and power was supplied from below through V-belts and appropriate pulleys to rotate the heater at 13 revolutions per minute. The heater with end plates was 33 in. (81.3 cm.) long and 16 in. (40.6 cm.) in diameter. One door carried an insulated cylinder with five slip rings, three of which supplied power to the heater windings and two of which acted as thermocouple connexions. Copper brushes carried current to the slip rings and made contact between thermocouple and Micromax temperature recorder and controller. Control of the furnace was fixed at the middle, using an iron-constantan couple. The temperature gradient from the middle to the doors was quite small (only a few degrees at 200°C.). Suitable resistances and relays in conjunction with the Micromax served to keep the heater to within about ±3°C. of the required temperature at all times.

The solvents were Eastman's highest purity chemicals except for cetyl alcohol, *n*-hexanol, and *m*-cresol, which were the practical grade, and ethanol (95%, U.S. Industrial Alcohol Company), benzene (Mallinckrodt Chemical Works, thiophene-free analytical reagent), Cellosolve, Carbitol, and dioxane (Carbide & Carbon Chemicals Corporation). The last three were distilled once, and the middle fraction was used. The other solvents were used without further purification.

The extractions were carried out as follows : Four clean bombs were prepared for use with each solvent. Five grammes of −200-mesh coal were weighed out and carefully brushed into each bomb. Then 100 c.c. of the solvent measured at room temperature were added, the air was displaced as completely as possible with nitrogen, and the head was closed. Increasing or decreasing the amount of solvent by 10 to 20% did not produce a change in yield greater than the experimental error. Since such tests were made at 200° and 300°C. with the best solvents, it is probably safe to assume that the solvent was never completely saturated with extract. The bombs containing the coal and solvent were placed in the heater at half-hour intervals to prevent excessive cooling of the aluminium cylinder. One bomb was removed at the end of 72 hours, one at 96 hours, and the last two at 120 hours. This procedure was used to determine

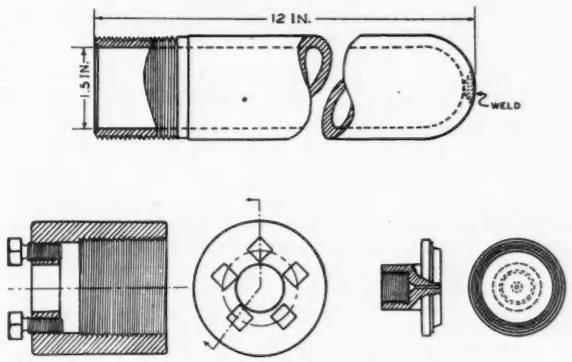

FIG. 1.—*Diagram of Bombs.*

if the yield at 120 hours was on the flat portion of the time *vs.* yield curve, where any additional time would result in only a small increase in yield. In the case of the extractions carried out at 150° and 250°C., only two runs at 120 hours were made. After the bomb was cooled, the gas pressure release was opened and the entire head was removed. The contents, consisting of a mixture of coal residue, extract, and solvent, were washed out with a 1 to 1 mixture of 95% ethanol and benzene, and generally a light brushing removed the last traces of material. The entire contents of the bomb in ethanol-benzene were then filtered through a weighed Alundum thimble (medium porosity) inserted in a medium-size Pyrex-glass Soxhlet extractor. At the end of the filtering period the thimble and contents were extracted with ethanol-benzene in an atmosphere of nitrogen for 120 hours to remove all traces of extract and solvent from the residue. In general, the extraction was completed in 3 to 4 days, the last 24 hours of extraction resulting in recoveries of only about 5 to 15 mg. of material. The coal residue which remained in the Alundum thimble after extraction was freed of ethanol-benzene, dried overnight at 110°C., weighed, and sampled for elementary analysis.

The material separated from the residue by filtration and Soxhlet extraction was combined and heated on a water bath to remove the ethanol-benzene. Further distillation on a water bath at about 6 mm. pressure followed by 2 hours of vacuum treatment at the same temperature and pressure generally sufficed to free the extract of the original solvent and ethanol-benzene. To remove the higher boiling solvents, it occasionally became necessary to use oil baths or vacuum sublimation apparatus in which the temperature was kept as close to 100°C. as was possible (generally not over 120°C.). In other cases, after removal of the ethanol-benzene, the extract and original solvent were poured into an aqueous solution of hydrochloric acid or sodium hydroxide, depending on the chemical nature of the solvent, to precipitate the extract which was filtered out and

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dried. The use of some low-boiling solvent was imperative for cleaning the bombs and for the Soxhlet extractions. The ethanol-benzene mixture was chosen because either constituent or the mixture was capable of dissolving the original solvent. The Soxhlet extraction could not be carried out easily with additional original solvent since in many cases the boiling points of these solvents were above the temperature at which the bomb extractions were carried out. Qualitative tests on the thoroughness of the ethanol-benzene extraction indicated that the material soluble in the original solvent was again redissolved in the 5-day Soxhlet extraction. These tests were somewhat complicated by the fact that, in general, once the solvent has been removed, the extract cannot be again completely dissolved in the original solvent.

The extracts from the 120-hour runs after weighing were combined and sampled for elementary analysis and ether solubility determinations. This procedure of combining the products of the duplicate extractions for analysis upon which the reported yield is based is not entirely satisfactory, since it gives no indication of the experimental error in the work. The reproducibility of the results as determined by various checks appears to average about $\pm 8\%$ of the reported yield. When this programme was about half completed, the supply of original coal sample was exhausted, and a new sample was ground from the same original coal and to the same maximum particle size—*i.e.*, −200 mesh. To make sure that no differences existed in the coal samples, some of the earlier work was duplicated. It was found that the two samples gave results which agreed within the experimental error. For the ether solubility tests, the dried extract was shaken with ethyl ether (700 c.c. per gramme of extract) and allowed to stand overnight in stoppered flasks, and the ether-insoluble material was filtered off and weighed.

Results

Since material balances in solvent extraction generally differ from 100%, owing to difficulties in completely removing solvent from extract and residue, and since the mineral matter is largely retained in the residue, the numerical value for the yield of extract obtained is dependent on the basis used for reporting the experimental data. In the present work five possibilities were considered : (1) on recovery of carbon, (carbon in $E \times 100$) /(total carbon in $E + R$) ; (2) on recovery of organic material, $(E - \text{ash}_e \times 100)/(E + R - \text{ash}_{\text{total}})$; (3) on organic material of the original coal, $(E - \text{ash}_e \times 100)/(K - \text{ash}_k)$; (4) on the residue, $(K - R \times 100)/(K)$; and (5) on the residue corrected for ash, $[(K - \text{ash}_k) - (R - \text{ash}_r) \times 100]/(K - \text{ash}_k)$, where E, R, and K represent the weight of extract, residue, or coal, and ash_e, ash_r, and ash_k represent the weight of ash in the extract, residue, or coal. Method 1, which is really a means of determining carbon balances, is hardly satisfactory for calculation of yield since it assumes the same chemical composition for the extract and coal. Methods 4 and 5 were seriously considered because it was felt that material balances over 100% resulted from failure to remove all of the original solvent from the extract. In several experiments the high balances may have been caused by a chemical combination between the solvent and the extract and/or the residue, and in some cases analysis of the products indicated that the solvent was combined to a larger extent with the extract. However, the evidence obtained did not appear to justify calculation of yields on the basis of the residue, particularly since this procedure includes all errors in the extract. The third method ignores the question of balances, and the second method distributes error due to imperfect balances between extract and residue in direct proportion to their amounts. The justification for the use of an ash-free basis for determining yields lies in the fact that practically all runs gave ash balances of over 100%. The foreign material was probably picked up from the bombs and Alundum thimbles. In view of these considerations, all yields reported in this paper were calculated on the basis of recovery of organic material (method 2). Oxidation of the extract and residue, for which no correction was made, probably contributed to the high balances, to some extent.

The yields of extract of Edenborn coal with six solvents at 150°C., forty-five solvents at 200°, five solvents at 250°, and twelve solvents at 300°C., together with certain physical properties of the solvent at these temperatures, are given in Table I. The twelve solvents studied at 300°C. were those used at 200°C. which were shown by experiment to be stable at this higher temperature in the presence of coal. No data are available for yields above 300°C. since even as low as 335°C. the large amount of gas formed in the 120-hour extraction period indicated that rather drastic decomposition of the coal was taking place. The solvents used at 150° and 250°C. were selected by a method which will be explained later.

Some additional solvents (carbon tetrachloride, nitrobenzene, catechol, benzaldehyde, benzoic acid, α-naphthol, carbon disulphide, *p*-chlorophenol, furfuryl alcohol, morpholine, bromoform, thiophene, and ethyl carbonate) not shown in Table I were tested at 200°C. These solvents decomposed or reacted with the coal to such an extent that no true value for yield could be obtained. In the case of furfuryl alcohol, polymerization to a hard black mass, insoluble in all solvents tried, occurred. At 300°C. α-naphthol gave a yield of extract of more than 60%, but the solvent was entirely transformed to α-dinaphthylene oxide ; the hydrogen liberated was probably responsible for the high yield. The yield of extract obtained with tetrahydronaphthalene at 300°C. was not included in the table because hydrogen balances between the extract, residue, and coal were about 120%[3].

A statistical analysis was made of the values of yield of extract, and various physical properties of the solvent used at 200°C., since at this temperature the large number of solvents and their diverse nature would increase the significance of any relationship which might be found. Among the properties considered were internal pressure, surface tension, dipole moment, dielectric constant, latent heat of vaporization at the boiling point and at the temperature studied, refractive index, specific refraction, molecular volume, parachor, and ratio of the square of the dipole moment to dielectric constant[1]. Of this group, internal pressure gave the most significant relationship to yield as shown by correlation coefficients[4]. Lack of information on physical properties of the solvent at the temperatures studied made it necessary to estimate these values both by interpolation and extrapolation of the data reported for other temperatures.

In calculating internal pressures at each temperature, it was necessary to assemble data on latent heats of vaporization and densities at that temperature for all solvents. Since latent heats at the boiling point were lacking for many solvents, it was first necessary to estimate them. Hildebrand's method[5] was used in which compounds of known heats of vaporization and of similar structure are taken as reference substances.

Values of latent heats at the temperatures studied were estimated from latent heats at the boiling points by Watson's method[12] from a plot of $(ML/T)f$ against reduced temperature (temperature/critical temperature, T_c), where ML/T is the molal entropy of vaporization and f is a factor by which this quantity for each solvent must be multiplied to bring all the points on to a single curve. Then if a known value of molal entropy of vaporization is $(ML/T)_1$ at a temperature T_1 corresponding to a reduced temperature T_1/T_c, the value at any other reduced temperature can be estimated from the relation :

$$\left(\frac{ML}{T}\right)_2 = \frac{y_2}{y_1}\left(\frac{ML}{T}\right)_1$$

where y_1, y_2 = values of ordinates corresponding to T_1/T_c and T_2/T_c.

Critical temperatures, unknown except in a few cases, were estimated by the simple Guldberg relation :

$$T_c/T_{B.P.} = 1.5$$

With hexyl and cetyl alcohols it was possible to calculate a constant similar to the Guldberg constant by extrapolation from known critical temperatures of lower alcohols.

To calculate densities, use was made of the Herz equation :

$$D - D_c = \frac{D_0 = D_c}{T_c^n}(T_c - T)^n$$

where D − density at T ° K,
D_c = critical density,
D_0 − density at 0° K.

Lautié[8] gives a value for n of 0.4. Where two values of density were known at different temperatures, it was possible to plot density against $(1 - T_r)^{0.4}$ and from these two values to extrapolate the line to a point corresponding to the temperature studied from which the value of density could be read. In the cases where only one value of density was known, use was made of the equation given by Lautié,

$$D_0 - 4\,D_c$$

which, in conjunction with the previous equation, gave :

$$D_c = \frac{D}{3(1 - T_r)^{0.4} + 1}$$

Hence it became possible on a plot of density against $(1 - T_r)^{0.4}$ to locate the critical density and the known value. A point on the line connecting the two gave the desired value of density.

TABLE I.—YIELD OF EXTRACT FROM A PITTSBURGH SEAM COAL AT SEVERAL TEMPERATURES AND PHYSICAL DATA OF SOLVENTS.

Solvent.	Based on Recovery of Organic Material. % yield.	% balance.	Density, D.	Molal Heat of Vaporization, ML_v, Kg. cal./mole.	Internal Pressure. P_i,Cal/c.c.
Temperature 150°C.					
Ethylbenzene	4.5	100.5	0.753	8.37	53.5
p-Cymene	4.6	100.8	0.762	9.64	50.0
Toluene	5.7	100.0	0.750	7.26	52.2
Naphthalene	11.5	104.0	0.960	10.72	74.1
o-Phenylphenol	16.3	99.4	1.110	14.09	86.5
Phenol	21.0	105.7	0.955	12.65	120.0
Temperature 200°C.					
Cetyl alcohol	3.0	99.9	0.743	21.05	61.7
Cyclohexane	3.2	99.5	0.577	4.98	27.7
Heptane	4.8	97.6	0.495	5.30	21.6
Ethyl acetate	7.0	101.1	0.621	5.84	34.5
Ethylene glycol	7.6	100.2	0.929	11.76	162.2
Ethyl propronate	7.7	100.7	0.644	5.81	30.8
n-Propyl acetate	8.1	101.3	0.649	5.97	32.0
Isopropanol	8.1	101.5	0.545	5.30	39.6
Ethanol	8.3	100.6	0.556	5.45	54.4
Bibenzyl	9.1	97.9	0.888	13.76	62.7
p-Cymene	9.3	101.1	0.717	8.63	41.2
Benzene	9.7	100.6	0.661	5.17	35.8
Ethylbenzene	9.9	100.8	0.696	7.26	41.4
n-Propanol	9.9	102.8	0.592	6.73	57.2
Toluene	10.1	100.8	0.672	6.29	39.1
n-Butanol	10.9	101.5	0.610	7.97	57.9
Methyl ethyl ketone	11.0	102.0	0.555	4.89	30.2
p-Chlorotoluene *a*	11.1	102.5	0.880	8.45	52.4
Bromobenzene *b*	11.9	105.7	1.239	8.22	57.5
Carbitol	12.4	100.8	0.850	12.97	76.5
Cellosolve	12.6	101.3	0.746	9.86	74.1
p-Dichlorobenzene *c*	12.9	100.3	1.220	9.08	67.5
Phenyl ether	13.0	101.4	0.948	12.07	63.0
n-Hexanol	13.9	103.5	0.655	10.10	58.8
Biphenyl	14.0	100.2	0.928	12.50	69.8
Chlorobenzene *d*	14.2	101.7	0.896	7.41	59.7
Anisole	14.9	101.8	0.818	7.91	52.8
β-Phenyl ethyl alcohol	15.5	99.8	0.885	12.79	85.9
Naphthalene	15.6	100.3	0.875	10.05	62.3
Tetrahydronaphthalene	16.3	102.1	0.834	10.66	61.4
Dioxane	16.6	101.5	0.80	6.56	51.1
Phenyl salicylate	16.7	104.1	1.065	12.40	57.0
Quinoline *e*	17.4	103.3	0.914	11.13	72.2
Phenyl benzoate	19.4	108.5	1.115	13.58	71.2
Pyridine *f*	20.0	103.8	0.758	6.87	56.9
Methyl benzoate	20.1	106.4	0.930	11.60	72.9
Thymol	20.7	104.5	0.825	10.72	53.8
Methyl salicylate	20.8	106.7	1.030	14.81	94.0
Guaiacol	21.2	104.4	0.982	10.11	72.6
Cyclohexanol	21.7	105.5	0.811	9.91	72.7
Acetophenone	24.0	100.9	0.877	9.25	60.7
Aniline *g*	24.4	108.3	0.852	9.35	77.1
o-Phenylphenol	25.0	103.8	1.070	13.50	78.9
m-Cresol	31.4	105.8	0.905	10.85	83.0
Phenol	32.1	105.8	0.901	11.50	101.3
Temperature 250°C.					
p-Cymene	11.6	102.5	0.665	7.61	32.6
Ethylbenzene	11.7	103.1	0.625	6.13	30.0
Toluene	12.8	102.2	0.614	5.16	27.4
Naphthalene	17.8	102.7	0.787	9.12	49.7
o-Phenylphenol	33.2	110.1	1.026	12.71	70.4
Temperature 300°C.					
Toluene	16.0	100.2	0.487	2.74	8.5
p-Cymene	18.0	101.1	0.602	6.66	24.8
Ethylbenzene	20.0	101.8	0.528	4.42	16.3
Phenyl ether	24.6	100.3	0.861	10.24	46.1
Biphenyl	27.9	99.4	0.850	10.77	53.2
Naphthalene	29.6	102.1	0.675	8.12	36.8
Bibenzyl	34.0	100.8	0.815	12.00	48.7
Pyridine *h*	34.9	104.3	0.610	4.28	24.1
Phenol	39.7	104.4	0.867	8.91	71.7
m-Cresol	40.4	111.4	0.783	8.57	53.8
Aniline *i*	48.4	113.9	0.722	7.29	47.7
o-Phenylphenol	49.1	111.2	0.975	11.58	59.9

a Corrected for solvent on the basis of excess Cl ; yield = 10.7% ; balance = 97.8%.

The corrected yields and balances indicated in footnotes *a* to *i* are made on the assumption that the halogen or nitrogen is distributed through the extract and residue in direct proportion to the amount of each ; moreover, in the case of the corrections for the nitrogen-containing solvents, it was assumed that the original nitrogen of the coal was distributed proportionately between the extract and residue.

b Corrected for solvent on the basis of excess Br. ; yield = 9.2% ; balance = 97.8%.
c Corrected for solvent on the basis of excess Cl ; yield = 12.9% ; balance = 99.6%.
d Corrected for solvent on the basis of excess Cl ; yield = 14.2% ; balance = 100.8%.
e Corrected for solvent on the basis of excess N ; no change.
f Corrected for solvent on the basis of excess N ; yield = 20.1% ; balance = 99.7%.
g Corrected for solvent on the basis of excess N ; yield = 24.4% ; balance = 90.7%.
h Corrected for solvent on the basis of excess N ; yield = 34.9% ; balance = 102.7%.
i Corrected for solvent on the basis of excess N ; yield = 48.4% ; balance = 96.5%.

Following the above methods, values of densities and latent heats of vaporization at 150°, 200°, 250°, and 300°C. were obtained. From these values, internal pressures were calculated by Hildebrand's method(5) from the equation :

$$\text{internal pressure} = \frac{(ML_v - RT)(D)}{m} = \frac{\Delta E}{V} = P_i$$

where m = molecular weight of solvent,
R = gas constant, calories/° C.,
V = molecular volume, (m/D),
ΔE = energy of vaporization per mole.

Values of internal pressure are included in Table I for the various temperatures studied.

Because of the successful correlation of yield and internal pressure at 200°C., similar correlation studies were made with all solvents from the 200°C. list which were stable at 300°C., and with a small group of solvents selected from the 200°C. plot of yield on the basis of recovery of organic material against internal pressure at 150° and 250°C. This procedure was followed in order that data at four temperatures could be placed on a comparative basis. It should be pointed out that the high values of the correlation coefficients at 150° and 250°C. would lose some of their significance because of the small number of solvents studied if it were not for the fact that good correlations were obtained at 200° and 300°C. with larger numbers of solvents. The correlation coefficients obtained for the various groups of solvents, together with the equations of lines making the sum of the squares of the deviations of yield a minimum, are given in Table II. Although the values for the coefficients are given only for yields based on the recovery of organic material, similar values would be obtained for yields on any of the five bases considered earlier in this paper. In addition, the probability of no relation existing between yield and internal pressure has been calculated and found to be less than one in a hundred for the smaller groups of solvents, and considerably less than this for the forty-four solvents studied at 200°C. In obtaining the equations for yield *vs.* internal pressure, it was assumed that the relations were linear since insufficient data are at hand to indicate they should be otherwise. The equations for the 200° and 300°C. data (Table II) are not the same for the two groups of solvents which were studied at each of these temperatures. These differences are not significant since the probable errors in the constants of the equations are of such magnitude that the differences might be due to chance.

It is surprising that the correlation of yield with internal pressure is as high as observed when it is considered that the solvents used included such a wide variety of chemical compounds, many of which are strongly polar. In determining the correlation coefficients and equations given in Table II, the data for glycol were not used since they were not concordant with the other data ; at 200°C. ethylene glycol has the highest internal pressure and is one of the poorest solvents.

Fig. 2 is a plot of yield of extract against internal pressure for all solvents except glycol at 200° and 300°C. The line representing the 200°C. data is for the nonaliphatics for comparison with the results at 300°C. for this type of compound. Mathematical analysis of the data indicates that on a probability basis this line is not significantly different from a line representing all the solvents studied. The equation for the aliphatics, on the other hand, has a different slope. It has been further shown that the difference between nonaliphatics with and without hydroxyl is not significant. Fig. 3 is a plot yield of extract against internal pressure for solvents at 150°, 200°, 250°, and 300°C.

TABLE II.—CORRELATION COEFFICIENTS OF YIELD *Y*, BASED ON RECOVERY OF ORGANIC MATERIAL, *vs.* INTERNAL PRESSURE *Pi* AND EQUATIONS RELATING THOSE QUANTITIES AT SEVERAL TEMPERATURES.

Temp. °C.	Correlation Coefficient.	Equation.	Number of Solvents.
150	0.98	$Y = -7.36 + 0.247Pi$	6
200	0.98	$Y = -5.44 + 0.369Pi$	6
250	0.97	$Y = -3.06 + 0.487Pi$	5
300	0.91	$Y = 8.67 + 0.552Pi$	6
200	0.74	$Y = -1.55 + 0.274Pi$	44*a*
200	0.77	$Y = -2.08 + 0.300Pi$	31*b*
300	0.73	$Y = 14.31 + 0.429Pi$	12

a All solvents except glycol.
b Nonaliphatic solvents.

The yield of extract insoluble in a solvent of low internal pressure, such as ethyl ether or pentane, bears a direct relation to the internal pressure of the solvent with which the extract was originally obtained from the coal. If the yield of ether-insoluble material is taken as a measure of the primary degradation of the coal substance(9), then solvents of high internal pressure not only give higher yields of extract, but so do with less secondary decomposition. When the amount of ether-insoluble material is recalculated on the original coal basis (through the weights of extract found), correlation coefficients with internal pressure similar to those given in Table II are obtained.

To learn whether other physical properties besides internal pressure are independently important in determining yields, plots were made of the deviations of yields from the line at 200°C. shown in Fig. 2 against several of the physical properties given earlier in this paper. In all cases the scattering of points showed no regular trend, which indicates that these properties either have no influence or are automatically taken into con-

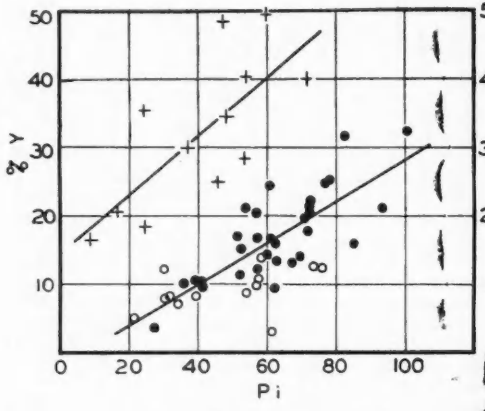

FIGURE 2. YIELD OF EXTRACT Y, BASED ON RECOVERY OF ORGANIC MATERIAL, *vs.* INTERNAL PRESSURE P_i AT 200° AND 300° C.

○ Aliphatic solvents at 200° C.
● Nonaliphatic solvents at 200° C.
+ Nonaliphatic solvents at 300° C.

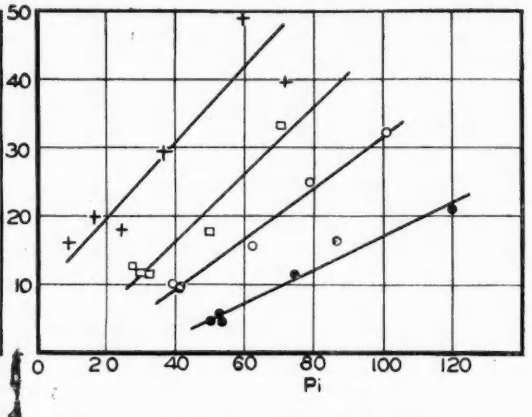

FIGURE 3. YIELD OF EXTRACT Y, BASED ON RECOVERY OF ORGANIC MATERIAL, *vs.* INTERNAL PRESSURE P_i

● 150° C., ○ 200° C., □ 250° C., + 300° C.

sideration in internal pressure. The latter is more probable in view of the fact that many physical properties are interrelated.

In an attempt to correlate surface tension with yield, it was found that a significant correlation at 200°C. was obtained only with the aliphatic solvents. No correlation was obtained at 300°C. (only nonaliphatic), and hence the slight correlation which might appear to exist at 150° and 250°C. (also nonaliphatic) is probably fortuitous. Surface tensions (γ) were obtained by interpolating between known values of γ at some temperature given in the literature, and γ at the critical temperature by means of a plot of γ against $(1 - T_r)^{1.2}$ from the equation[11] :

$$\gamma = \gamma_0(1 - T_r)^{1.2}$$

where T_r = reduced temperature,

γ_0 = a constant (γ for the supercooled liquid at 0° K).

Since internal pressure gave such a satisfactory correlation with yield, equations of the form,

$$Y = a + b\,P_i$$

where a, b = constants depending on temperature

were obtained. The general type of the equations might be interpreted provisionally as supporting the idea that the yield of extract is determined in part by the extent of thermal depolymerization of the coal and in part by the extent of solvent depolymerization of the coal. Also provisionally the fact that the value of constant a becomes positive somewhere between 250° and 300°C. may be interpreted to mean that within this temperature range thermal depolymerization has progressed to a stage where the products have a molecular weight of the order of 200–500, which is the range observed for extracts obtained with various solvents.

Although these studies of the effect of physical properties of a solvent on yield of extract from a bituminous coal have thrown some light on the mechanism of extraction, a question arises as to the effect of the chemical nature of a solvent. For example, is a basic solvent capable of removing certain constituents of the coal, while an acidic solvent removes others? In order to investigate this problem, extractions were carried out in which the residue obtained from an extraction of coal with phenol was re-extracted with aniline, a less powerful solvent ; practically no yield was obtained. Moreover, if the coal was first extracted with aniline and the resulting residue re-extracted with phenol, the total yield obtained was slightly less than was obtained with phenol alone. If each solvent removed specific constituents, the expected yield would have been greater than with phenol alone. Hence it may be inferred that the acidic or basic nature of the solvent is without effect (within the experimental accuracy) in determining yield. Similar results were obtained by Kuznetzov (7) with a Soxhlet type of extraction.

The Author wishes to acknowledge his indebtedness to the members of the staff of the Coal Research Laboratory for their help on this problem ; especially to R. S. Asbury who did much of the early work and to H. G. Landau for his suggestions and help in the mathematical analysis of experimental data.

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Gas Products Prices

The London Market

Dec. 2.

Prices of Tar Products remain unchanged at the following levels: Pitch is nominal; creosote is about 4⅜d. to 5d. per gallon; refined tar 3⅜d. to 4d.; the price of pure toluene under the Ministry of Supply Toluene No. 2 Order is 2s. 5d. per gallon; pure benzole is 1s. 10d.; 95/160 solvent naphtha is 1s. 11d. to 2s.; 90/160 pyridine about 15s.; all per gallon naked; refined naphthalene crystals £23 per ton in bags; all *ex* Makers' Works.

The Provinces

Dec. 2.

The average prices of gas-works products during the week were: Pitch and Crude Tar,* Toluole, naked, North, 1s. 10d. (controlled by the Control of Toluene No. 2 Order, July 5, which fixes the maximum price at which this material may be sold). Coal tar, crude naphtha, in bulk, North 9½d. to 10d. Solvent naphtha, naked, North, 1s. 9d. to 1s. 10d. Heavy naphtha, North, 1s. 5d. to 1s. 6d. Creosote, *ex* works, in bulk, North liquid and salty, 4½d. to 4⅜d.; Scotland, 4½d. to 4⅜d.; low gravity, 4½d. to 4⅜d. Fuel Grade 4d. to 4½d. Carbolic acid, 60's, 3s. 9d. to 3s. 10½d. Naphthalene, £15 to £20. Salts, 75s. to 85s., bags included. Anthracene, "A" quality, 4½d. to 4⅜d. per minimum 40% purely nominal. Heavy oil: Unfiltered anthracene oil (min. gr. 1,080), 5½d. to 5½d.; filtered heavy oil (min. gr. 1,080), 5⅜d. to 6d.; heavy anthracene oil gr. less than 1,080, 6d. to 6½d.

* In regard to pitch and crude tar prices we would ask readers to refer to the editorial note in our issue of Sept. 4, p. 404.

Tar Products in Scotland

GLASGOW, Nov. 30.

A moderate amount of new business has been placed for prompt delivery and negotiations for next year's delivery are now well advanced.

Refined tar remains in fair call for home use at 4½d. to 4⅜d. per gallon and for export at 3½d. to 3½d. per gallon, both f.o.r. naked.

Creosote oil is moving quite smoothly with makers' prices steady as under: Specification oil, 5d. to 5½d. per gallon; low gravity, 6d. to 6½d. per gallon; neutral oil, 5⅜d. to 6d. per gallon; all *ex* Works in bulk.

Cresylic acid.—There is very little demand, but makers are maintaining prices as follows: Pale, 99/100%, 2s. 1d. to 2s. 3d. per gallon; Pale, 97/99%, 1s. 10d. to 1s. 11d. per gallon; Dark, 97/99%, 1s. 6d. to 1s. 8d. per gallon; all *ex* Works in buyers' packages.

Crude naphtha.—According to quality available supplies command 6½d. to 7½d. per gallon *ex* Works in bulk.

Solvent naphtha.—90/160 grade is 1s. 8½d. to 1s. 9d. per gallon and 90/190 Heavy Naphtha is 1s. 4½d. to 1s. 5½d. per gallon.

Pyridine is in poor call at 17s. to 18s. per gallon for 90/160 grade and 19s. to 20s. per gallon for 90/140 grade.

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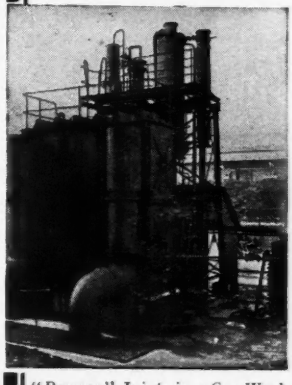

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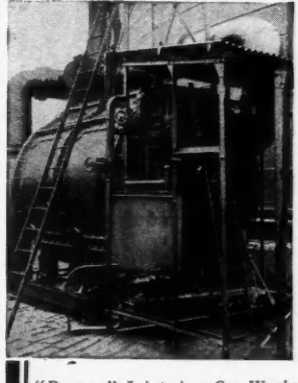

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GAS STOCKS AND SHARES

Most sections of the Stock Exchange maintained a steady tone throughout last week, and the feature was the strength of British Funds, which was partly attributable to the repayment of Canadian stocks—the level of 2½% Consols at 76 was the same as a week ago. Home rail stocks also remained firm, the juniors showing slight improvement. Industrials varied from day to day, and in contrast to the past few weeks the values of some of the "heavies" dropped on the South Durham dividend decision, but the bank and insurance groups were well supported. More interest was taken in oil shares, but rubbers and teas remained quiet.

The volume of business in the Gas Market was again heavier last week, and it will be seen that this further support coupled with more enquiries led to a few price improvements. Among the "ordinaries" South Suburban gained 2 to 64½, and Wandsworth 1 to 68½, but with the stock changing hands at 90 the Portsmouth quotation was marked down 7 points to 92½. Among the debenture stocks Gas Light 3% and South Suburban 5% both rose 2, and a few preference issues showed movements either way. On the Provincial Exchanges, Newcastle units hardened a further 6d. to 17s., and Liverpool ordinary advanced a point to 96. No changes occurred in the Supplementary List.

Doubtless many holders of gas ordinary stocks are apprehensive as regards final dividends for the current year. Much depends upon whether the localities served by the various undertakings are reception or evacuation areas, for the latter have been hit, in more than one sense of the word, somewhat severely, and it is possible that in some cases the distribution may be quite small compared with even a year ago.

Quotations on the London and Provincial Stock Exchanges

OFFICIAL LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 28.	Rise or Fall on week.
1,767,439	Sept. 16	7	7	Alliance & Dublin Ord. ...	102—112	...
374,000	July 1	4	4	Do. 4 p.c. Deb. ...	90—95	...
957,608	Nov. 4	5	5	Asscd. Gas & Water U'd'ts Ord.	12/—14/-	..
500,000	,,	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	15/6—17/6	...
535,545	,,	4	4	Do. 4 p.c. Red. Cum. Pref.	14/6—16/6	...
336,646	,,	4	4	Do. 4 p.c. Irred. Cum. Pref.	12/—14/-	..
561,370	Aug. 12	7	7	Barnet Ord. 7 p.c.	98—103	...
300,000	Oct. 14	1/9⅜	1/4⅜	Bombay, Ltd.	19/6—21/6	..
690,407	Aug. 19	7	7	Bournemouth 7 p.c. max ...	100—110	.
362,025	June 17	4	4	Do. 4 p.c. Deb. ...	75—85	...
659,955	Aug. 19	6¾	4⅜	Brighton, &c., 5 p.c. Con. ...	65—75	...
855,000	Sept 30	8	6	Brit. Gas Light Ord.	75—85	...
545,000	June 17	5½	5½	Do. 5½ p.c. 'B' Cum. Pref	110—115	..
120,000	,,	4	4	Do. 4 p.c. Red. Deb.	75—80	...
10,000	Nov. 6, '33	6	4	Cape Town, Ltd., 4½ p.c. Cu. Pf.	¼—¾	..
626,860	July 15	5 5/10	6	Cardiff Con. Ord.	89—94	...
24,500	Sept. 23	7	7	Colombo Ord. 7 p.c. Pref ...	19/—21/-	..
764,169	Oct. 7	/11.48	-/11.48	Colonial Gas Assn. Ltd. Ord. ...	14/—16/-	...
400,000	,,	1/3.30	1/3.30	Do. 8 p.c. Pref. ...	19/—21/-	...
1,748,935	July 22	2	3	Commercial Ord.	37—42	...
620,000	June 10	3	3	Do. 3 p.c. Deb.	58—63	.
286,344	Aug. 19	5	5	Do. 5 p.c. Deb.	87—92	.
807,560	Aug. 12	7	6	Croydon sliding scale	83—88	...
644,590	,,	5	5	Do. max. div.	79—84	...
620,385	July 1	5	5	Do. 5 p.c. Perp. Deb. ...	90—95	...
179,500	Aug. 19	5⅜	5	East Surrey 'B,' 5 p.c.	75—80	...
176,461	June 17	5	5	Do. 5 p.c. Deb. (Irred.)..	90—95	..
250,000	Nov. 11	4	6	Gas Consolidation Ord. 'B' ...	13/6—14/6	
250,000	Nov. 11	4	4	Do. 4 p.c. Red. Cum. Pref.	15/—17/-	...
19,152410	July 29	3⅜	4½	Gas Light & Coke Ord. ...	13/6—14/6	.
2,600,000	,,	3½	3½	Do. 3½ p.c. max. ...	50—55	
4,477,106	,,	4	4	Do. 4 p.c. Con. Pref. ...	71—76	+1
2,993,000	July 8	3¾	3¾	Do. 3¾ p.c. Red. Pref. ...	80—85	...
8,602,497	June 3	3	3	Do. 3 p.c. Con. Deb. ...	67—72	+2
3,642,770	,,	5	5	Do. 5 p.c. Red. Deb. ...	100—105	...
3,500,000	,,	4½	4½	Do. 4½ p.c. Red. Deb. ...	98—103	...
700,000	Sept. 9	3¼	3½	Do. 3½ Red. Deb. ...	80—85	.
5,600,000	May 13	4	8	Imperial Continental Cap. ...	35—40	...
43,820	July 29	3½	3½	Do. 3½ p.c. Red. Deb. ...	63—68	...
231,978	Aug. 19	5	5	M.S. Utility 'C' Cons.	68—73	..
918,657	,,	4	4	4 p.c. Cons. Pref.	72—77	..
675,000	Nov. 11	14	14	Montevideo, Ltd.	52—57	.
300,000	Nov. 13	7	9	Oriental, Ltd.	95—105	...
368,537	June 3	7	8	Plymouth & Stonehouse 5 p.c.	90—100	..
621,667	Aug. 19	8½	7½	Portsmouth & Gosport Cons.	93—95	—7
648,999	Sept. 16	1.1	1/1½	Severn Val. Gas Cor. Ld. Ord.	13/—15/-	...
597,972	,,	-/10½	-/13½	Do. 4½ p.c. Cum. Pref. ...	15/6—17/6	...
2,528,714	Sept. 2	1/-	-/7½	South East'n Gas Cn. Ld. Ord.	9/—11/-	...
1,000,000	,,	-/10½	-/12½	Do. 4½ p.c. Red. Cum. Pref.	14/—16/-	.
1,068,869	,,	4	4	Do. 4 p.c. Irred. Cum. Pref.	13/—15/-	...
6,709,895	Aug. 5	4	4	South Met. Ord.	53—58	.
1,135,812	,,	6	6	Do. 6 p.c. Irred. Pref. ...	95—105	..
850,000	,,	4	4	Do. 4 p.c. Irred. Pref. ...	69—74	+1
1,895,445	July 1	3	3	Do. 3 p.c. Perp. Deb. ...	60—65	..
1,000,000	July 15	5	5	Do. 5 p.c. Red. Deb. ...	95—100	..
1,543,795	July 22	3	4	South Suburban Ord. 5 p.c. ...	62—67	+2
512,825	July 8	5	5	Do. 5 p.c. Perp. Pref. ...	85—90	—3
500,000	,,	4	4	Do. 4 p.c. Perp. Pref. ...	60—65	—2½
250,000	,,	3¾	3¾	Do. 3¾ p.c. Red. Pref. ...	80—85	..
888,587	June 10	5	5	Do. 5 p.c. Perp. Deb. ...	92—97	+2
750,541	Aug 9	5½	5	Southampton Ord.	58—63	..
350,000	Feb. 12	5½	5½	Swansea 5½ p.c. Red. Pref. ...	91—96	...
1,076,495	Aug. 5	5	5	Tottenham & District Ord. ...	62—67	...
338,555	,,	5	5	Do. 5 p.c. Pref.	78—83	...
453,380	June 10	4	4	Do. 4 p.c. Perp. Deb. ...	75—80	—3
1,247,505	May 20	4	6	U. Kingdom Gas Cor. Ord. ...	13/—15/-	..
1,085,932	Nov. 25	4½	4½	Do. 4½ p.c. 1st Cum. Pref.	13/8—15/6*	..
772,709	,,	4	4	Do. 4 p.c. 1st Red. Cum. Pref.	13/—15/-*	..
745,263	June 17	4½	4½	Do. 4½ p.c. 2nd Non-Cum. Pf.	12/6—14/6	...
1,200,000	Sept. 9	3½	3½	Do. 3½ p.c. Red. Deb. ...	82—87	...
380,606	Aug. 5	7	6¾	Uxbridge, &c., 5 p.c.	80—90	...
1,371,138	July 8	3½	4	Wandsworth Consolidated ...	66—71	+1
2,525,768	,,	4	4	Do. 4 p.c. Pref.	60—65	..
1,343,964	June 17	5	5	Do. 5 p.c. Deb.	90—95	..
383,745	,,	4	4	Do. 4 p.c. Deb.	80—85	...
558,342	July 15	6	5	Watford & St. Albans Ord. ...	88—93	..
300,000	June 10	3½	3½	Do. 3½ p.c. Red. Deb. ..	85—90	.

SUPPLEMENTARY LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 28	Rise or Fall on week.
351,685	June 17	5	5	Brighton, &c., 5 p.c. Perp. Deb.	90—95	...
28,700	,, 17	5½	5½	Do. 5½ p.c. Red. Deb. 1942 ...	96—101	..
415,250	,, 17	4	4	Bristol Gas Co., 4 p.c. New Deb.	85—90	..
140,205	July 29	7	7	Cambridge, &c., 7 p.c. Cons. 'B'	100—110	...
295,932	Aug. 19	5	5	Cheltenham, 5 p.c. Cons. Ord....	88—93	...
42,500	July 1	4	4	Do. 4 p.c. Perp. Deb....	82—87	...
150,000	Aug. 12	4	4	Croydon Gas, 4 p.c. Pref. (Irr.)	65—75	...
130,000	July 1	4	4	Do. 4 p.c. Deb. ...	75—80	...
146,700	Aug. 19	5½	5½	East Surrey, 5½ p.c. Pref. 'A' ...	90—95	..
53,220	,, 19	6	6	Do. 6 p.c. Cum. Pref. ...	95—100	...
117,425	Feb. 5	8	8	East Wight, 5 p.c. Cons. Ord. ...	100—110	...
...	Aug. 19	6	4	Eastbourne, 'B' 3½ p.c....	65—75	...
239,135	Nov. 11	5	5	Gas Consolidation 'A' Ord. (£1)	13/—15/-	..
156,600	Aug. 19	5	5	Hampton C't, 5 p.c. Cons. Ord.	68 —73	...
18,000	June 10	7	7	Malta & Med'n., 7 p.c. 1st Pref.	60—65	...
10,845	,, 10	7½	7½	Do. 7½ p.c. 2nd Pref.	60—65	...
50,000	Aug. 19	£5 19 6	£5 4 6	Mid. South. Util., 'A' Cons. 5 p.c.	63—73	...
65,000	Aug. 12	5	5	North Middlesex, 5 p.c. Pref. ...	87—92	...
70,000	Sept. 9	5	5	Plymouth & Stone., 5 p.c. Deb	87—92	..
76,501	July 1	4	4	Reading, 4 p.c. Perp. Deb. ...	75—80	...
74,777	Sept. 30	4	4	Romford, 4 p.c. Debs. (Reg.) ...	77—82	...
21,000	June 10	5	5	Slough, 5 p.c. Perp. Deb. ...	90—95	...
211,740	,, 17	5	5	Southampton, 5 p.c. Red. Deb.	96—101	...
363,575	July 1	5	5	Tottenham, 5 p.c. Reg. Red. Mt.	95—100	..
202,019	Oct. 14	6¼	6¼	Tunbridge Wells, 4 p.c. Scale ...	70—80	..
135,257	June 10	5	5	Uxbridge &c., 5 p.c. Perp. Deb.	90—95	..

PROVINCIAL EXCHANGES

					Quotations Nov. 22.	
47,756	July 26	6	5	Bath Cons.	95—100	...
122,577	July 22	7	6	Blyth 5 p.c. Ord.	100—105	..
1,667,250	July 15	5	5	Bristol, 5 p.c. max.	91—93	...
120,420	June 17	4	4	Do. 1st 4 p.c. Deb.	94—96	...
415,250	,,	4	4	Do. 2nd 4 p.c. Deb. ...	92—95	...
328,790	,,	5	5	Do. 5 p.c. Deb.	108—111	...
157,150	Aug. 5	6½	5	Chester 5 p.c. Ord.	98—101	...
92,500	June 17	4	4	Do. 4 p.c. Pref.	80—85	...
36,430	,,	3½	3½	Do. 3½ p.c. Deb.	80—85	...
41,890	,,	4	4	Do. 4 p.c. Red. Deb. ...	94—98	...
542,270	Aug. 12	9	6	Derby Cons.	100—105	...
55,000	June 10	4	4	Do. 4 p.c. Deb.	96—102	...
10,000	Aug. 19	10	10	Great Grimsby 'A' Ord. ...	165—175	...
6,500	,,	10	10	Do. 'B' Ord. ...	165—175	...
79,000	,,	10	10	Do. 'C' Ord. ...	155—165	...
732,000	Aug. 26	4	4	Hartlepool G. & W. Cn. & New	61—63	...
2,167,410	Aug. 19	6	6	Liverpool 5 p.c. Ord. ...	95—97	+1
245,500	June 17	5	5	Do. 5 p.c. Red. Pref. ...	97½—100½	...
306,083	July 15	4	4	Do. 4 p.c. Deb.	99—101	..
20,000	June 24	5	5	Long Eaton 5 p.c. Pref.	9—11	...
80,000	June 24	5	5	Do. 5 p.c. Deb.	100—105	...
2,430,267	July 29	5 7/10	5	Newcastle and Gateshead Con.	16.6—17/6a	+/6
682,856	,,	4	4	Do. 4 p.c. Pref.	74—76	..
776,706	Dec. 27	3½	3½	Do. 3½ p.c. Deb.	80—85	—3
277,285	April 24	5	5	Do. 5 p.c. Deb. '43 ...	97—102	...
274,000	July 26	5	5	Newport (Mon.) Ord.	89—93	...
13,200	Sept. 16	8½	7	Pontyp'l Gas & W. 10 p.c. 'A'	11½—12½	...
13,600	,,	6	5	Do. 7 p.c. 'B'	9½—10½	...
40,000	,,	5	6	Do. 7 p.c. 'C'	9½—10½	...
106,280	Aug. 5	8	10	Preston 'A' 10 p.c.	157—167	...
188,219	,,	7	7	Do. 'B' 7 p.c.	113—123	..
1,806,339	Aug. 26	6½	6½	Sheffield Cons.	118—120	...
95,000	July 8	4	4	Do. 4 p.c. Deb.	97— 99	...
332,351	Feb. 5	6	6	Sunderland 6 p.c. max. ...	107—112	..
140,778	Aug. 12	5	5	Weston-super-Mare Cons. ...	85—95	...
64,338	June 24	4	4	Do. 4 p.c. Deb.	75—85	...
33,340	,,	7½	7½	Do. 7½ p.c. Deb.	137—145	...

a—The quotation is per £1 of Stock. * Ex. div. † Price free of income-tax.

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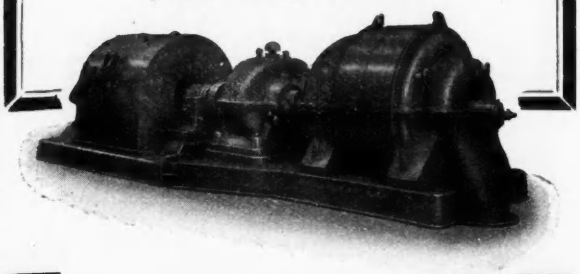

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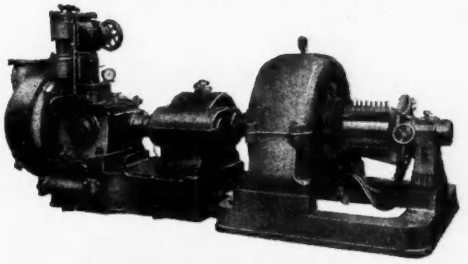

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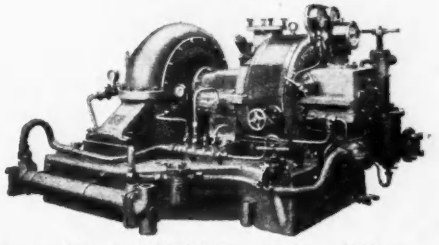

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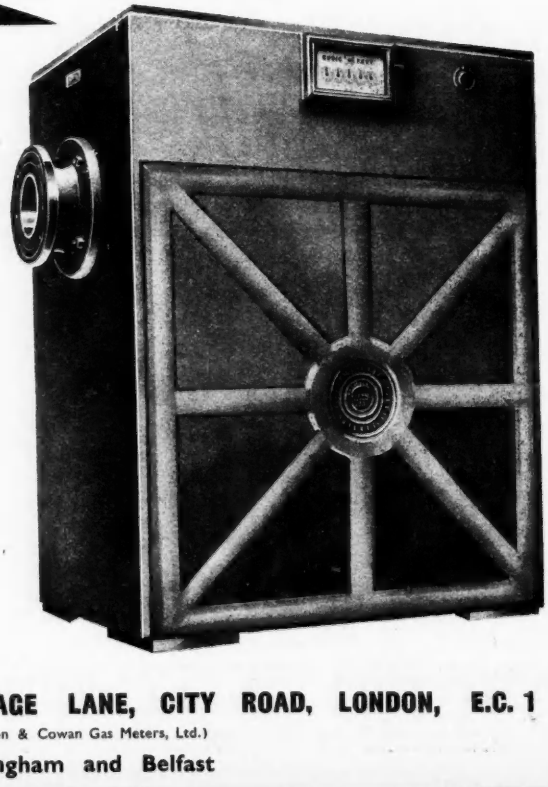

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